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Exploring Intervisibility Networks: A Case Study From Bronze and Iron Age Istria (Croatia and Slovenia)

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Abstract

Using the rich archaeological record of 480 hillfort sites during the Bronze and Iron Age in Istria (Croatia and Slovenia), we have attempted to build a structured approach for investigating intervisibility networks. This analysis is organized in three steps. An exploratory analysis of visual connections is first carried out, particularly focusing on the relationship between the lengths of connection between sites and the network structure. Next, two new indices of integration of individual sites into the network are proposed and analyzed (connection success and visual neighborhood index). Finally, an approach for examining the statistical relevance of the observed network is proposed.

Keywords*:* Visibility Analysis, Intervisibility Network, Gis, Prehistory

Introduction

The first interpretation of prehistoric hillfort sites in Istria, a peninsula in the Northern Adriatic Sea (Figure 1) was proposed by the local historian Pietro Kandler in the mid-19th century. This promoted the idea of a vast network of mutually visible fortresses which were dated erroneously to the Roman period. Their visual connection would have enabled coordinated actions for defensive or commanding purposes (Kandler, 1869; Buršić-Matijašić, 2007: 577). This anecdote reveals a deep-rooted fascination for intervisibility phenomena, not only in Istria but in many other regions where hilltop sites abound (Crete – Soetens *et al.* , 2008; Bosnia – Benac 1985; Slovenia – Dular & Tecco Hvala, 2007; Spain – Brughmans *et al.*, 2014).

Intervisibility can be considered as a visual relationship between two socially meaningful entities: two persons, two communities, or even those of spirits or ancestors. These relationships constitute a particular type of social network, i.e. they facilitate and channel social contact (Hillier ,2005). Likewise, they participate in structuring the social space by forging visual references to particular places or constructions (Tilley, 1994, 6). In terms of the long standing debate over shortcomings of visibility analyses in landscape archaeology, that is, their limitation for understanding complex social and cognitive phenomena, the intervisibility analysis is particularly interesting because of both, its explicit addressing of intentionality or at least directionality of the gaze, and its focus on complex relationships (Frieman & Gillings, 2007; Llobera, 2012).

A crucial problem of intervisibility analysis is the relationship between the observed structure (the patterns of visual connections) and the practice which is related to the function of these connections. First, it cannot be denied that many societies, including those inhabiting prehistoric Istria, developed 'strategies of visibility' rendering certain aspects of social life more visible than others (e.g. funerary monuments [Criado, 1995]). However, this 'will to visibility' as F. Criado puts it, does not need to be conscious or rationalized (ibid). The structure may emerge as a result of complex social processes rather than direct intentionality, which is, perhaps, the essential argument of the structuralist approach (Murdoch, 2005). Hence there is a need for an in-depth analysis of the observed structure, in particular testing for the possibility of random emergence (cf. Wheatley, 1995; Brughmans *et al.*, 2014). We do, nevertheless, consider a functional hypothesis in the case of the Istrian intervisibility network: that the intervisibility network facilitated communication exchange. However, it should be noted that the examination of that hypothesis is a research incentive more than its presumed goal. The principal aim of the following analysis is to propose a methodological framework for the study of intervisibility networks as prerequisite for consideration of any functional interpretation.

The analysis is organised through a three-tiered scheme. First, we begin with an exploratory analysis of visual connections with particular attention to distances between sites. Next a connectivity analysis is performed, which is done using two new metrics, along with the standard index of betweenness centrality. Third, as a means of testing the relevance of the observed patterns (i.e. for their potentially random emergence), a background intervisibility network of all Istrian hilltops is modelled and compared against the observed network of archaeological sites.

1. Dataset and methodology

The prehistory of Istria is best known for castellieri, modestly sized Bronze and Iron Age hillforts (1 to 5 ha in surface), surrounded by one or several massive ramparts (Mihovilić, 2013). Large amounts of pottery, as well as settlement debris and traces of architecture found in excavations, indicate that the majority of sites were inhabited. Some sites display apparent indicators of higher status, either in terms of their size, imported goods or particularly rich necropoles that emerged in their vicinity (Hänsel *et al.*, 2009; Buršić-Matijašić, 2007). The density of the distribution of these sites in the region is remarkable — the distances between sites are less than 2 km on average (Table 1).

There are, however, many uncertainties regarding Istrian hillforts. The excavations tend to focus on large, high status sites, while little is known about small, less intensively inhabited sites. Many could have served as pastoral enclosures, especially in the mountainous and karstic areas (Slapšak, 1995), or even as observation outposts (Teržan & Turk, 2005). Another problem, related to the lack of research, is insufficient data on the chronology of the sites: the vast majority is dated roughly to 'protohistory' (Buršić-Matijašić, 2007). A recent study of the Northern part of Istria by M. Sakara-Sučević (2012) has shown that six out of nine sites examined could have been contemporary in the Middle or beginning of Late Bronze Age. In southern Istria, a vast majority of hillforts is supposed to be established in the Bronze Age, while fewer continued in the Iron Age (Hänsel *et al.*, 2009; Buršić-Matijašić, 2007). In any case, a conclusive survey is yet to be made, but broad contemporaneity of a large number of sites (roughly two thirds or more) may be hypothesized for the Middle to Late Bronze Age.

The dataset presented here has been compiled mainly from an exhaustive catalogue by K. Buršić-Matijašić (2007) for the Croatian part of Istria, and S. Poglajen (2007) for the Slovenian part. The 'hypothetical' group from the catalogue of K. Buršić-Matijašić has been retained in order to account for possible lack in the verified part of the dataset (Figure 1). The hypothetical sites tend to gather in the less researched interior of the peninsula, which may play a crucial role for assessing the integrity of the intervisibility network. All analyses were run parallel, with and without hypothetical sites.

Standard viewshed analysis, implemented in many GIS software packages, can be used for the purpose of analysing intervisibility relationships (Wheatley, 1995). However, this approach poses a significant computational overhead because the usual viewshed algorithm verifies all potential target points in a given radius, while in our case only a very limited number of target points is of interest. Massive viewshed calculations can take days of computing on a common personal computer (Llobera *et al.*, 2010).

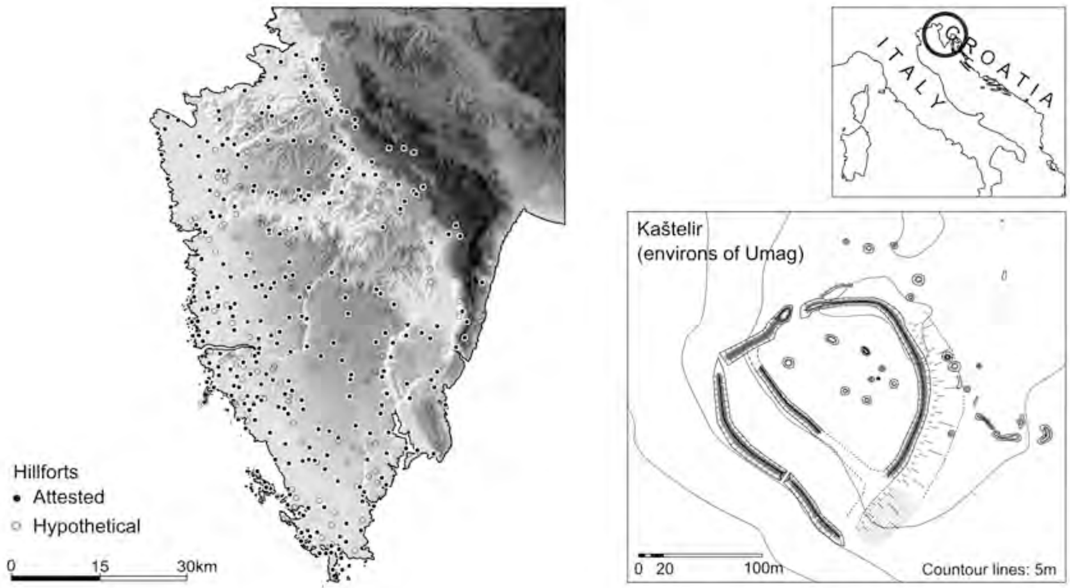

Figure 1: Hillforts of Istria with an example of a site (elevation data: SRTM).

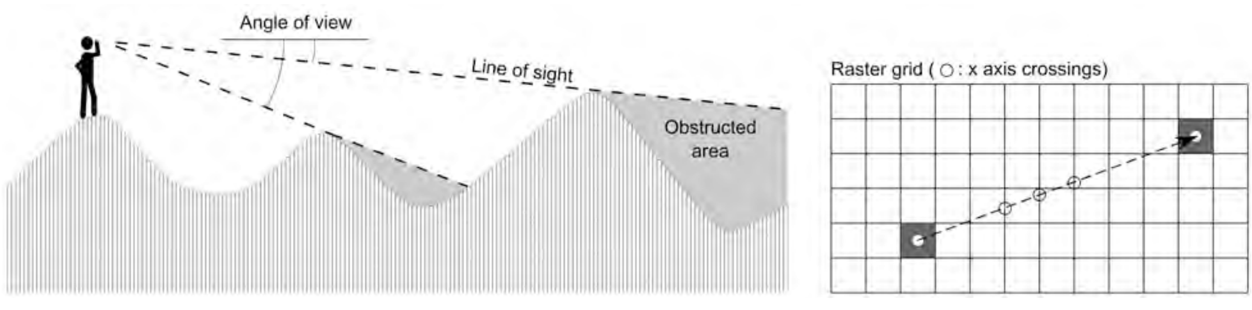

Figure 2: Intervisibility calculation.

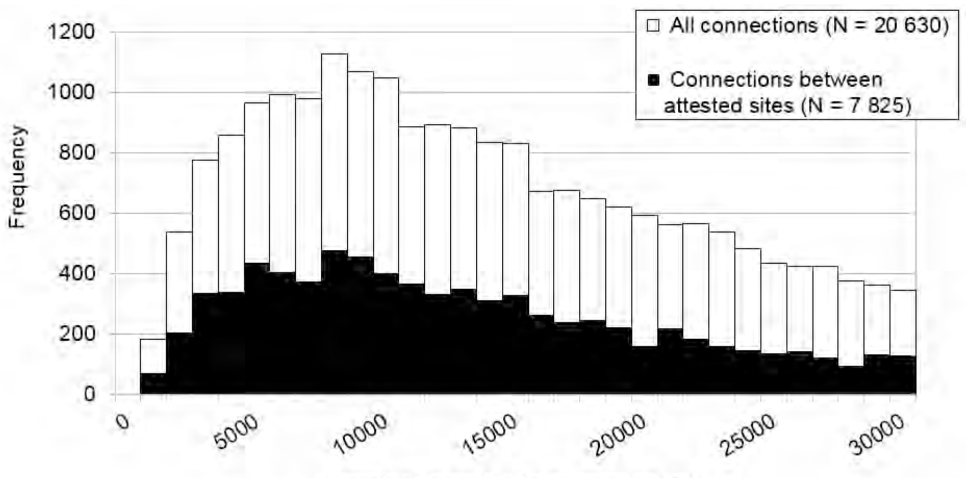

Figure 3. Histogram of in,tervisibility connection lengths.

For the purpose of efficient analysis as well as generation of an appropriate data format for network analysis (a list of pairs of connected nodes with some supplementary data), a customized intervisibility algorithm was implemented in QuantumGIS software (Čučković, 2014). The algorithm calculates the vertical angle of view towards each pixel traversed by a straight line connecting the observer and the target (Figure 2). The target is visible if situated above the maximum angle of view. Note that the straight line will rarely touch the centre of intermediary pixels (Figure 2, right): the height values are, therefore, interpolated between two neighbouring pixels on each side of the tested line, which is the common or 'exact' visibility calculation (Kaučič & Žalik, 2002).

Free SRTM data was used for the digital elevation model (DEM), with the resolution of three arc seconds, corresponding to 80 meters in the local projection (Farr *et al.*, 2007). More precise data of ASTER GDEM[1] (30 meters resolution), also available free of charge, are unfortunately very noisy in the studied area and not as detailed as might be expected for the nominal resolution. Although coarse resolution of the SRTM DEM is definitely problematic for typical viewshed analysis which deals with a handful of sites in a restricted area, it may be argued that large numbers of sites, studied over a large area (here 90 x 60 km), would bring some additional robustness to the analysis (cf. Fisher et al. 1997 for use of a 50 m DEM).

2. Assembling the network

The intervisibility relationships were calculated for observers with height (from eye level) of 4 meters, accounting for massive drystone ramparts recorded on many excavated sites (Hänsel *et al.*, 1999; Buršić-Matijašić, 2007:513). The observer point was placed in the approximate centre of each site. Only reciprocal visibility was considered, i.e. if site A sees site B, the same should be valid the other way around.[2]

[1] ASTER GDEM is a product of METI and NASA.

[2] Non-reciprocal visibility relationships may be an important feature at close range, as in the case of surveillance systems (cf. Yekutieli 2006). However, at longer distances considered here such relations seem unlikely, especially if exchange of communication is hypothesized.

The histogram displayed in Figure 3 summarizes lengths of visual connections between Istrian hillforts. The highest frequency of connections is in the range of 5 to 10 kilometers with a peak at 7 kilometers. Apparently, these are the ranges which contribute the most to the formation of the hypothesised network, which can be further verified by its visualisation (Figure 4). The network layout settles down to a shape corresponding loosely to the geographical shape of Istria at a 7 to 10 kilometer distance ('Force Atlas' layout algorithm implemented in Gephi software was used). That effect is less evident when hypothetical sites are filtered out, because those are more frequent in the interior of the peninsula, which plays a crucial role for the network integrity.

Simple as it may be, the first step in the analysis of the intervisibility connections reveals a crucial relationship between network integrity and the distance of connections. The network becomes a region-wide phenomenon when connections of 7 or more kilometres are allowed, while at 5 km most parts of Istria already get integrated. The range of 5 to 10 km is also the most frequent in the distribution of connection lengths, which may explain the ranges at which the intervisibility network would have most efficiently operated. This finding may be further used to define distance based ranges that shape contact and communication. The near range would be situated at less than 5 km from the site. Individual features of neighbouring sites can still be discerned, large ramparts in particular, and even acoustic communication can be established.[3] The middle range, on the other hand, which covers distance from 5 to 10 km, offers a larger number of visual connections so that potential messages may be passed on with fewer intermediaries over greater distances. Finally, in far ranges, at distances beyond 10 or 15 km, only large landscape features remain visible and communication

[3] Drumming, for example, can be very effective means of communication even beyond 5 km (Finnegan 2012, chap. 17)

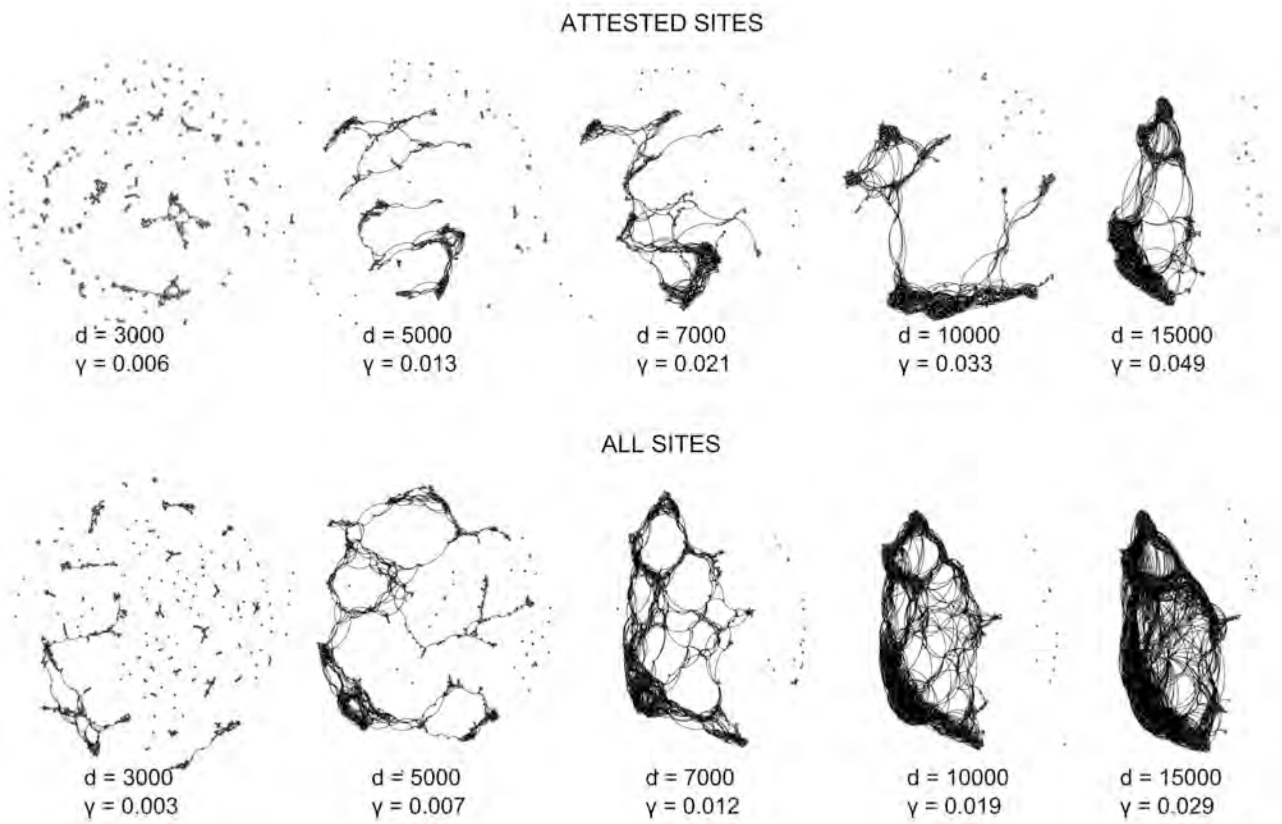

Figure 4: Progressive network integration in relation to increase of the maximum allowed connection distance (d, in meters). γ denotes graph density.
(Graph density is calculated by dividing the number of observed links by the maximum possible number of links (everybody connected to everybody - Newman 2010, chap. 6.9))

exchange becomes complicated. However, a practice of visual referencing of prominent (symbolically charged) features may still result in intervisibility networks.

3. Measuring connection

If a standard viewshed from a chosen observer point can be quantified by absolute values such as surface, average angle of view, shape etc., in the intervisibility network, which is composed of pairs of connected nodes exclusively, we have to rely on measures relative to the context of local or overall connections in the network. Additionally, the knowledge of spatial locations of analysed sites can be used to evaluate the connected sites against other available but disconnected sites in the vicinity (i.e. in the same radius of analysis; Figure 5).

Two basic intervisibility indices have been developed. Connection success of a site is defined as the percentage of the visible target sites in a set of evaluated target sites. A simple node degree (i.e. the number of connections per site), is less meaningful since it does not account for the number of available sites in the vicinity. Visual neighbourhood index is obtained by subtracting the median length of unsuccessful connections from the median length of successful connections. Negative values will, thus, indicate 'myopic' sites which keep their connections in the closer range, while sites having mostly far reaching connections will have positive index. The calculation is made on medians rather than on averages of distances because these values tend to have large variances: most commonly tested locations are spread all over the analysed zone. Note that both metrics are relative to the local context rather than to the overall configuration of the intervisibility network: their purpose is chiefly in measuring local responses to the potential for visual connection.

In order to study the integration of individual sites into a possible global flow in the network, one classic metric has been chosen as well: betweenness centrality. This metric is calculated by counting how many shortest (or optimal) paths between all pairs of nodes in a network pass through each individual node (Newman, 2010, chap. 7.7) It is very useful for detecting 'bottleneck' nodes which act as bridges connecting different clusters in the network (also known as 'hub nodes'). In the case of the Istrian intervisibility network, the betweenness centrality may help to locate sites having an important role in maintaining the integrity of the network.

Our indices were, then, obtained using the intervisibility algorithm at the search radius of 7.5 km, which is in the hypothesized optimal distance range (supra). The output produced by the algorithm, a table of both successful and unsuccessful connections, makes the calculation of proposed intervisibility indices a rather straightforward procedure. The histogram of connection success (Figure 6) displays a slight bimodal distribution, as if there may be a group of better and a group of less connected sites. The visual neighbourhood index mostly in the negative range, indicating (expectedly) that most of the sites keep their connections in the closer range. However, there are some 'long-sighted' sites which stand out from this 'myopic' majority, and which tend to connect farther away within their 7.5 km neighbourhood. In the scatter plot on Figure 6 the individual sites are distributed according to the two indices. No tendency of correlation between the success of connection and visual neighbourhood index is apparent. The spread of points indicates that even sites with long connections do not necessarily have a good success.

The relevance of these abstract metrics for understanding real-world archaeological sites can be illustrated by the two following examples (Figure 7). The site of Krug has both success of connection and visual neighbourhood index in the medium range. The hillfort itself is small to medium sized (1.8 ha) and single walled, situated on a dominant hilltop in the north of Istria (Buršić-Matijašić, 2007: 441). Its dating is not quite certain, but the surface pottery assemblage seems to indicate the Bronze Age. Krug would be an ordinary Istrian hillfort if it didn't have one of the highest betweenness centrality values in the intervisibility network (especially when the maximum connection distance is set above 7 km) (Figure 6). The second example, located at the lower left of the scatter plot where sites with poor connection success and short connection distances gather, is the site of Kaštelir near Nova Vas (Figure 7). The site is exceptionally large for

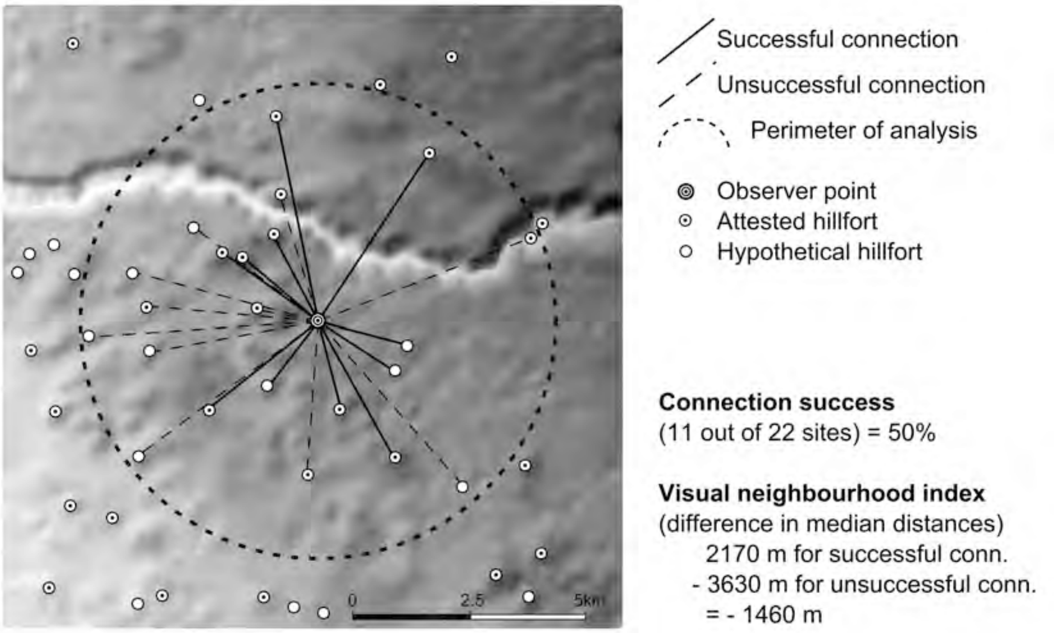

Figure 5: Calculation of intervisibility indices: the observer point corresponds to Maklavun tumulus near Rovinj (Hänsel et al. 2009).

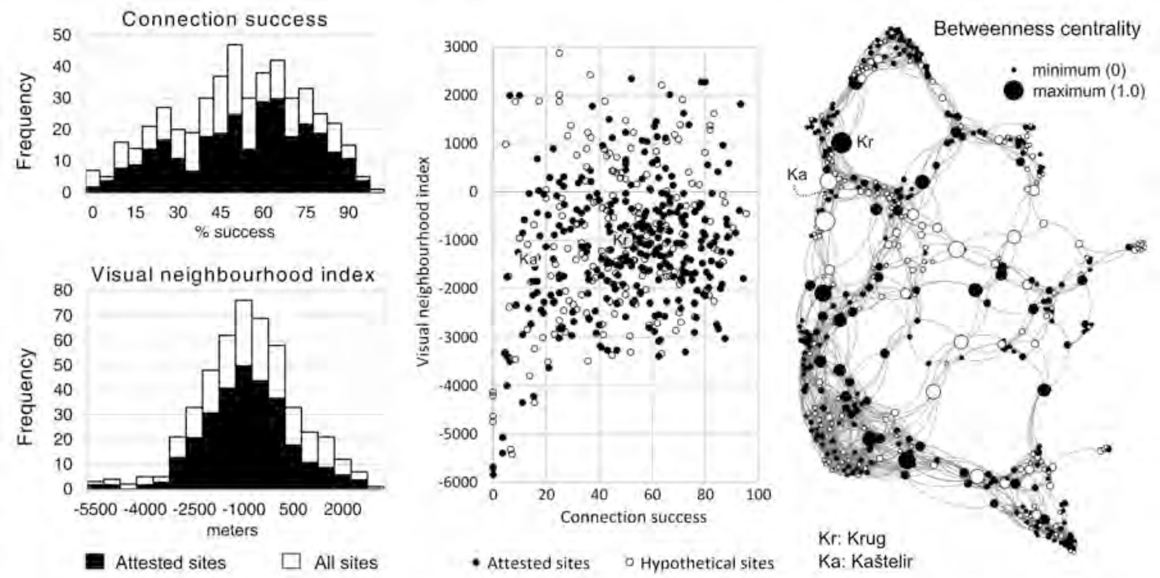

Figure 6: Intervisibility indices for analysis radius of 7.5 km.

Istrian prehistory (13 ha), and after a Bronze Age phase it became a local centre in the Iron Age (Sakara-Sučević, 2004). A glance on its topographic position – surrounded on all sides by higher ground – belies bad placement in terms of visual dominance. In fact it has only 5 visual links and measures of its connectivity are insignificant. However, the site is connected to two major hubs in terms of their betweenness centrality (Figure 6: just above and below the site), albeit both are considered as hypothetical sites.

While in the case of Krug the visual connections may have played a role in the choice of the location of the site (note the high betweenness centrality), this is definitely not true for the important settlement of Kaštelir. Apparently, intervisibility connections (or visibility in general) are not directly related to the settlement status. In fact, well connected sites tend to occupy high spots which are more often than not surrounded by rugged and poor terrain, less attractive for agricultural practices. Some of those may even have had surveillance and intervisibility connection as their primary function, as in the case of the probable Iron Age observation tower from Ostri Vrh in Slovenia.[4] In effect, the evidence of complex surveillance strategies in the Iron Age suggests that larger sites, such as Kaštelir, could still be well connected to the network through particular, intermediary sites. Such a higher level of complexity still remains to be tackled.

4. Testing for relevance

By scattering observers in the landscape according to a spatially random process, some of the observers should see each other thus creating an intervisibility network. Landscape has inherent visual connectivity. The observed prehistoric network should, then, differ significantly from such a random set if it has been shaped by particular, non-random processes.

A very popular method for statistical testing of intervisibility was proposed by David Wheatley. Essentially, his method uses viewshed surfaces generated from the analysed

[4] The tower is a massive drystone structure of oval shape, 11 meters long, with walls 1.5 to 2.5 meters in thickness, perched on top of a steep, rocky hill. Calibrated radiocarbon dates are in the range of 8th to 5th century BC. The excavators interpret the structure as an element of a surveillance system over an important land passage (Teržan & Turk 2005).

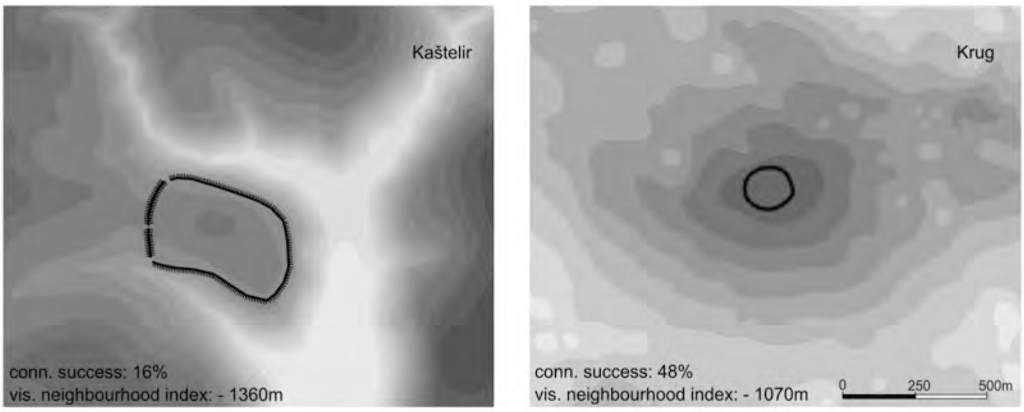

Figure 7: Sites Kaštelir near Brtonigla and Krug near Buje (same scale).

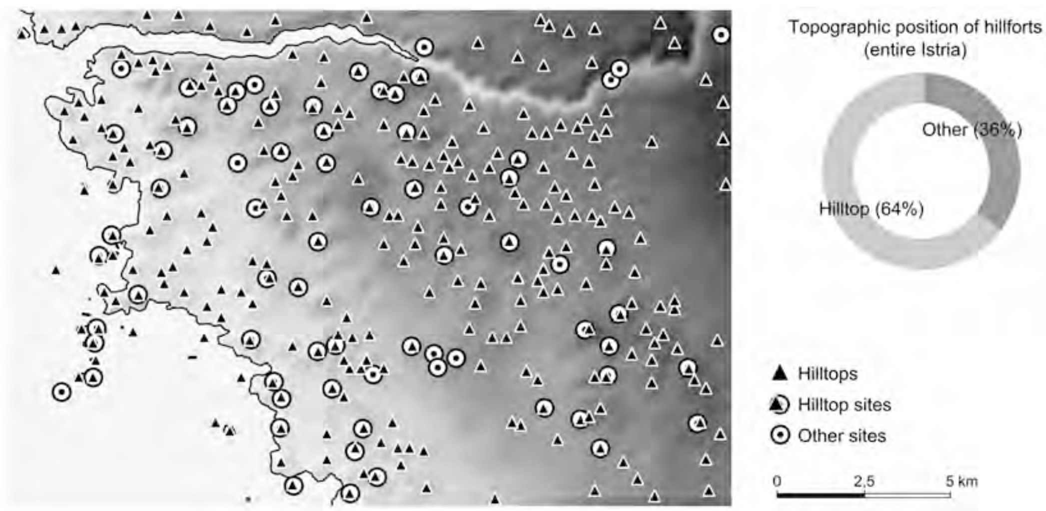

Figure 8: Correspondence of hilltops and prehistoric hillforts (map coverage: surroundings of Rovinj).

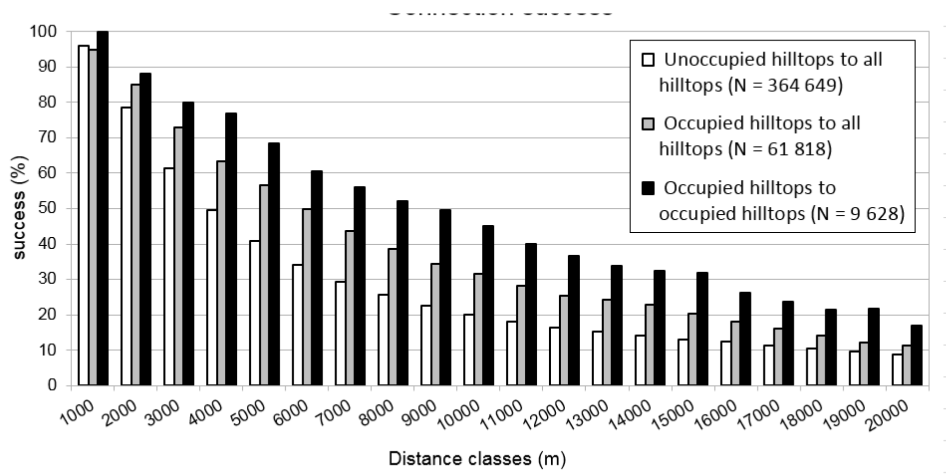

FIGURE 9: CONNECTION SUCCESS OF ANALYSED HILLTOP POPULATION.

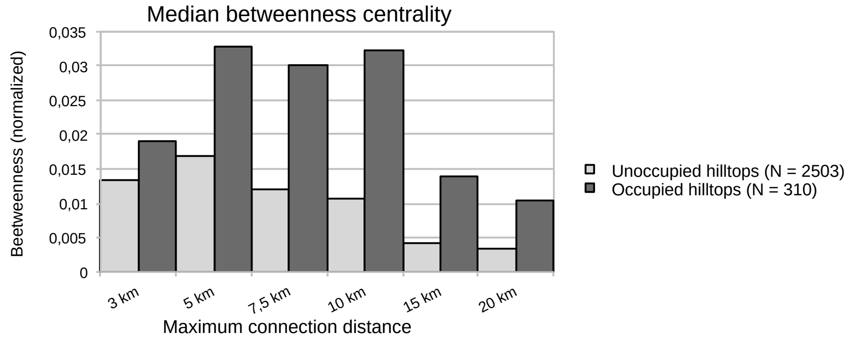

FIGURE 10: MEDIAN BETWEENNESS CENTRALITY FOR DISTANCE BASED MODELS OF THE HILLTOP INTERVISIBILITY NETWORK.

locations (i.e. sites) and tests whether the same sites tend to gather in zones with dense viewshed overlaps (Wheatley, 1995). However, that method operates in a uniform, indiscriminate space; the null hypothesis is that sites had equal chances of being placed anywhere in the landscape. That may work for some types of sites, such as prehistoric tumuli analysed by Wheatley, but not for hillforts which, by definition, occupy hills or elevated positions.

In order to develop a test more appropriate for our dataset, the background population of possible hillfort locations was reduced exclusively to hill-tops. These are defined as locations (here pixels in the DEM) which have the highest height value in a radius of 250 meters. Setting this radius to smaller values (equivalent to one or two pixels size) will likely result in selecting insignificant 'noise' in the DEM.[5] Close to two thirds of site locations (64%) correspond to the applied hilltop criteria (Figure 8). Apparently, many hillforts occupy other types of topographic positions, such as ridges or spurs, which have to be isolated by more sophisticated methods.[6] Nevertheless, the obtained sample of 2.813 hilltop sites, of which 310 occupied during the period under study, seems solid enough for statistical analysis, even if obviously biased by virtue of applied topographic criteria.

The intervisibility analysis was repeated on the sample of extracted hilltops, but with the observer and target heights set to two meters, considering these locations to be devoid of particular constructions (i.e. higher than half a metre). The same observer height was used regardless of the eventual prehistoric occupation of hilltops, in order to provide an unambiguous basis for statistical comparison. The complexity of the obtained network is enormous: more than 400 000 visual connections for the analysis radius of 20 km. Regarding the presence of archaeological evidence on the observer and target locations, three types of connections are considered here: 1) unoccupied hilltops to all hilltops, 2) occupied hilltops to all hilltops, and 3) occupied hilltops to each other.

The histogram on Figure 9 shows the connection success (i.e. the percentage of successful links) for one-kilometre wide distance ranges.[7] A strong tendency towards better connection between occupied hilltops is apparent. The statistics of betweenness centrality was calculated for six network models, each defined by the maximum distance allowed for establishing visual connection (Figure 10). These values have very large variances, and their

[5] The noise, i.e. insignificant topographic prominences or simply fluctuations of the DEM, is difficult to avoid in any case. For the purpose of our analysis 'hilltops' less than a meter in height and situated in completely flat areas were manually deleted.

[6] Another problem is the definition of hillfort which is inevitably ambiguous. Preferably, it is 1) relatively large site, 2) delimited by massive rampart and 3) situated on an elevated position. However, not all of these criteria are met in cases such as coastal hillforts or small, possibly seasonally occupied hillforts (cf. Buršić-Matijašić 2007, 485ff.)

[7] Previously discussed connection success index evaluates the success of individual sites while here the links are grouped according to their length, regardless of sites they connect.

distribution is extremely skewed, which is otherwise typical of this metric (Newman, 2010: chap. 7.7). Therefore, medians rather than means were used. Again, occupied hilltops differ from unoccupied ones, in particular after 5 km, which corroborates with the previous observation that the visual connections tend to concentrate in the range from 5 to 10 km. In order to verify statistically the observed differences in betweenness centrality the non-parametric Wilcoxon-Mann-Whitney test, which compares median differences of two samples, was used (Table 2). A very small (< 0.2) effect size of all differences should be noted, which indicates that these populations still resemble each other very much, even if their differences are statistically significant ($p < 0.05$).[8]

Further clues on the character of the intervisibility network can be obtained through graph theory, namely by examining the statistical distribution of node degrees (i.e. number of links per node). The simplest networks, formed by the random selection of links created with a set probability (called Bernoulli or Erdős-Rényi random graphs), will have a binomial or Poisson degree distribution (Newman 2010, chap. 12.3). Indeed, that is precisely the case with the intervisibility network of all hilltops (Figure 11). Much the same is valid for the population of all hillforts in the dataset, but the statistic becomes more interesting when hypothetical sites are eliminated. A tendency towards dispersion in degree distribution can be discerned in the group of attested hilltop sites (Figure 11). The network of hilltop sites, thus, features a higher proportion of well-connected nodes (with normalized degrees above 0.5), at least in comparison with the network of all hilltops. However, the exact relationship between these networks, including possible differences from a random pattern, should be tested by more advanced methods (see esp. Brughmans *et al.*, 2014).

It can be concluded now that hilltop sites play a key role in the connectivity of the network and that intervisibility relationships did influence choices of site location, which seems less clear for other, non-hilltop archaeological sites. Indeed, the bias introduced by selecting hilltop sites enabled at the same time to filter out sites with poor connection potential.

Conclusion and perspectives

It is hoped that the analysis of Istrian prehistoric hillforts demonstrated the existence of a web of intervisibility relations as a distinct cultural phenomenon. A consistent tendency towards settlement locations offering better intervisibility connections is discernible, particularly at the middle distance range (between 5 and 10, at maximum 15 km). Distance is apparently a key variable for understanding intervisibility networks, not only in terms of presumed function (see below), but also in terms of the potential for visual communication offered by the landscape. Nevertheless, intervisibility studies often present network models with connections ranging from 0 to beyond 30 km (e.g. Dular *et al.*, 2007; Soetens *et al.*, 2008). In the outlook, an exploration of interplay between near, medium and far distance ranges (as proposed above) in the intervisibility network is envisaged, aided by modelling networks where connections are weighted by distance.

Two new indices for the insertion of sites into the intervisibility network are proposed: the connection success and the visual neighbourhood index. Both make use of data that are absent from the intervisibility network, namely the unsuccessful connections to sites which are close by but hidden from sight. Such an approach is explicitly local inasmuch as it evaluates individual responses of sites to the intervisibility network. Consequently, the proposed

[8] The effect size was calculated as $r = z / \sqrt{N}$, where z is the z-score and N the number of all observations (Fritz et al. 2012). wilcox.test and wilcox_test functions from R software, with paired option set to False, were used for obtaining these values. The basic assumption of the Wilcoxon-Mann-Whitney test is that groups have similar distributions, while conformity to normal distribution is not required (Wilcox 2009, 273).

Radius of analysis	3 km	5 km	7.5 km	10 km	15 km	20 km
W	342391	304235	284040	276330	268640	275264
p	0,0007562	5,72E-010	< 2,2e-16	< 2,2e-16	< 2,2e-16	< 2.2e-16
Effect size (r)	0,06	0,12	0,15	0,16	0,17	0,16

Table 2: Results of Wilcoxon-Mann-Whitney test for betweenness metric.

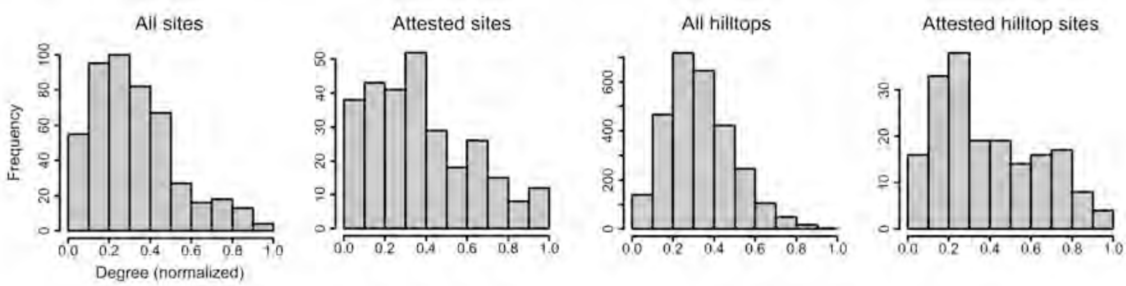

Figure 11: Degree distributions for networks with maximum connection distance of 7.5 km.

indices may be better suited for evaluating sites in their local context than the node degree metric, as demonstrated on cases of two hillforts. Many more parameters can be evaluated in the same manner, such as azimuths of connections or types of sites engaged. Such elaborate data may be used to investigate an experiential context of a site (i.e. visual references with the surrounding landscape), as well as to nuance the often globalising approach of the network analysis.

Testing for statistical relevance of the intervisibility network is not an easy endeavour. It was not possible to use the elegant and very popular solution by D. Wheatly (1995) which tests the observed population against uniform spatial distributions – our sites are normally on hilltops. All Istrian hilltops were therefore isolated as the background population of potential sites and analysed using the intervisibility algorithm. This approach is useful, but comes with an important caveat. Moving away from the expectation of uniform spatial distribution, we're stepping into predictive modelling (Verhagen & Whitley, 2012). That would certainty introduce a new scale of complexity, but would also enable evaluating intervisibility against other factors in the choice of site locations, such as topography, environment or social relationships.

The question of the use to which the intervisibility network had been put was not tackled. Formal characteristics of the network (such as its density and positive tendency for higher betweenness centrality) might be interpreted in favour of a communication exchange network, for example by smoke and fire.[9] Nevertheless, there is still no archaeological evidence in its support (beacons, particular traces of burning etc.). Moreover, some other processes may give rise to a well-connected network, such as the establishment of visual references to other occupations in the landscape, with or without intention for regular communication (cf. Marrou & Rousseaux, 2009). In any case, these hypotheses need to be tested by more sophisticated approaches. An interesting approach is recently introduced Exponential Random Graph Modelling which is based on the generation probabilistic networks (i.e. where connections are defined by varying probabilities) (Brughmans *et al.*, 2014). Its application on the intervisibility network of Iron Age sites in the Southern Spain has enabled researchers to propose the tendency of small scale, local clustering of visual connections around dominating sites as the crucial process in the emergence of the network (idem, 452).

The aim of this paper is in presenting a structured approach to intervisibility network analysis, working from the ground level up, that is, from exploratory data analysis to more complex issues. Not finding an ultimate interpretation for the functioning of the intervisibility network is not a weakness. Intervisibility studies are often accompanied with problematic concepts and quick conclusions, which have been subject to critique (cf. Briault, 2007). Diving deeper into the complexity of visual networks and examining them in their own right is crucial if these critiques are to be confronted.

[9] Smoke and fire are often mentioned in the ancient sources (Homer, Illiad, XVIII, 210-213; Aeshylus, Agammemnon, 1-34). A fire signalling network has also been recently proposed for Bronze Age Crete (Sarris et al. 2011).

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