THE INNER GEOGRAPHY OF HILL-TOP TOWNS
A DISCUSSION ON THE EFFECTS OF ALTIMETRY ON CONFIGURATION

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ABSTRACT

Space syntax as a theory and methodology is widely applied and appreciated for its capability of extracting relevant cognitive data and information of generative processes out of the spatial layout of urban settlements. Nonetheless, the different operational techniques introduced so far share the prevailing (if not exclusive) interest towards the planimetric consistency of the urban settlements, taking for granted the irrelevance of orography, as implicitly assumed as not effective and hence negligible. Here altimetry is taken into play, discussing its role on configuration as well as on the distribution of centrality. I propose a new configurational technique, suitable for appraising the orographic features of the grid, then presenting the results of its test on several case studies corresponding to steep urban settlements.
The findings imply that also the altimetric features of a settlement are implicitly enclosed within the grid configuration, internalized within its variables. Even more, space syntax is recognized suitable for describing the way an urban settlement fits the specific orographic condition of the site, that's to say the way its use is actually made possible in the local geographic context.

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FORMA CIVITATIS: International journal of urban and territorial morphological studies (IJUTMS), Vol. 1, N. 1, 2021

Backgrounds

Over the years the correspondence between configuration and centrality has been widely explored, and the finding of several researches allows assuming centrality as a process, depending on the spatial relationships between the elements of the grid, rather than a functional or material state (Hillier, 1999a).

In fact, if we assume centrality in terms of attractiveness and then appreciate it by the density of activities actually located along the streets of an urban grid, a significant correlation narrowly joins it to the distribution of the integration value (Cutini, 2001): what allows to assert integration suitable for reproducing the distribution of centrality within an urban settlement. On the other hand, the cases of discordance between integration and attractiveness, when they actually emerge, can easily be ascribed to local and contingent elements, due in particular to the presence of specific monopolistic activities, which do not suffer from an unfavourable position on the grid; still, their location can only attract movement and then other activities, so as to influence the distribution of centrality (Cutini, 2001). Summing up, such distortion appears much more to confirm than to confute the correspondence between configuration and centrality and the primary influence of the first one on the latter.

Those findings, in that they testify the effect of spatial relations on accessibility and centrality, actually highlight the key theme of spatial impedance, around which sharp studies have been so far discussed (Batty, 2004; Batty, 2010): how those relations are to be appraised and measured, so that their configuration can narrowly reproduce the impedance that space creates.

As a matter of fact, the results above mentioned derive from the configurational analysis of a wide set of urban grids, many of which are anything but flat and regular: among them, several Italian medieval cities, castled on top hills, altimetrically irregular and densely provided with precipitous paths (Bortoli, Cutini, 2001). Nonetheless, even those cases fully confirm the correlation of centrality versus configuration, although it emerges from a plain disregard of such relevant orographic features. Therefore it would be interesting to investigate if (and how, and to what extent) the appreciation of altimetry can modify and improve those results, so as to provide a stronger and more reliable correlation.

The indifference towards the third dimension has been one of the recurring remarks on space syntax, since the matter was raised by Carlo Ratti among his inconsistencies (Ratti, 2004), soon rejected (Hillier, Penn, 2004). Nonetheless, in such case the neglected third dimension was only referred to the height of buildings, and its disregard was charged to involve the disregard of people and activities inside, assumed as origin or destination of interaction and movement flows. In other words, it was actually much more a matter of land use rather than a question of third dimension. On such issue, Ratti himself proposes a three-dimensional representation, the urban digital elevation model (DEM), suitable for storing and processing data regarding also the heights of buildings, so as to complement space syntax (Ratti, 2005).

Other proposed extensions towards a three-dimensional approach actually concern (Wang et al., 2007) the influence of the spatial perception of the urban image points on people's behaviour and movement choices; in that case, the attempt is to integrate the configurational approach with the theory of the image of the city (Lynch, 1960) rather than to construct an actual three-dimensional configurational approach. In other words, all the mentioned methods actually focus on the three-dimensional elements that lie on the grid, rather than on the third dimension of the grid itself.

If the importance of some vertical transition was variously highlighted over the years (Chang, Penn, 1998; Chang, 2002; Arnold, 2011; Hölscher, et al.,2012; Lu & Ye, 2017; Zhang, Chiaradia, 2020), yet such attention was mainly addressed to discuss and predict multilevel pedestrian movement. The first specific attempts to analyse an urban grid overcoming the limits of a strictly three-dimensional view seem to be traceable in the 'extended axial curves' (Asami et al., 2003) and in the 'mark points' (Cutini et al., 2004).

The system of Ma.P.P.A. - Mark Point Parameter Analysis (Cutini et al., 2004) - is constructed reducing the urban grid into a set of singular points, selected as corresponding to several specific features (middle points of squares, deviation points of road-centre lines, intersection points of road-centre lines, and so on) and imported with their coordinates from an existing geographical information system. The Ma.P.P.A. was presented as suitable for providing nearly the same configurational indices of Visibility Graph Analysis, that is mainly neighbourhood size, control value and, above all, integration value. Such method was expressly suggested as naturally available for a significant three-dimensional development, if only the mark points were appraised with their third coordinate, that is their respective altitude.

Methodology

On the basis of the discussion so far, a convenient (or, better said, natural) base for the three-dimensional development of space syntax appears to be the mark points parameter analysis. The axial analysis (either linear or angular) can't in fact take into account any altimetric variable, as based on systems of lines that connect three-dimensional convex spaces. Nor can visibility graph analysis do, since its vertices too are assumed as points of view of flat viewsheds. Road-centre line analysis (Turner, 2007) and other network analysis techniques focusing on road-centre lines (Porta et al., 2006) could perhaps be developed in a three-dimensional direction: yet, as a matter of fact such operation appears everything but easy, since it requires the data of each road-centre line to be provided with its slope value, in order to compute its impedance according to the respective steepness. Moreover, since it focuses only on the streets network, the road-centre analysis can't take into account the distribution of altimetry along a single straight line, nor the change of altimetry within a square.

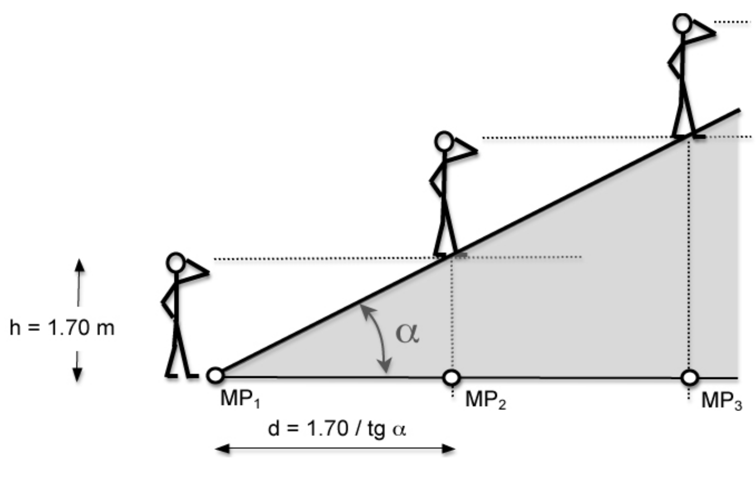
The mark points of Ma.P.P.A., on the contrary, as automatically imported from an existing database management system with their respective territorial coordinates, are naturally provided with a complete set of geometric features, including the altimetric one (Cutini et al., 2012). The choice of introducing the third dimension by means of the development of the mark point parameter analysis involves the use of GIS, either in data importing and in the management and representation of results. The matter therefore regards the way of using their altitude attribute to upload the slope of their mutual connection, so as to determine a different appraisal of their spatial impedance.

In order to appraise altitude without renouncing the topological approach to the urban space, the proposed idea is to analyse the actual slope between any couple of mark points and then to assume a horizontal viewshed from a height of 1,70 metres: in case two adjacent mark points should not result in direct visual connection, one more point will be interposed. Summing up, the effect of slope on spatial impedance is actually materialised by the gathering of mark points along the steep paths, what makes mutually deeper their terminal points: the steeper is the connection between two adjacent mark points, the higher will result the number of the new interposed points. Such a method hence allows to preserve the configurational conceptual basis of the theory (that is the primary role of the grid and the focus on the spatial relationships between its elements), to retain the

topological appraisal of the spatial impedance (by means of the number of the interposed mark points along the shortest path) and to introduce the effect of orography and slope on the input variables of the system. From an operational point of view, it is previously necessary to construct the Digital Territorial Model and the Digital Elevation Model of the grid, and hence, on their basis, the slope representation, which reproduces the distribution of slope within the inner space of the settlement. It is then possible to highlight the steep connections between couples of mark points and to analyse their respective longitudinal profile, in order to interpose a new mark point, should the two adjacent ones not be in mutual visual connection, assuming. The introduction of a new mark point at a distance d, as referred to the assumed height of the point of view, hence depends on the angle α of descent, in that is α = arctg 1.70/d, as shown in figure 1.
The new introduced mark points are then transferred into the DEM to integrate with the pre-existing others into the system: the processing of the model can finally provide the configurational variables, which are represented in a point shape file as the several attributes of each mark point.

Analysis and results
1. The results of the proposed method
As a matter of fact, the potential effects of altimetric variables are likely not to affect the configurational pattern of most urban settlement, if their inner geography is characterised by a flat (or almost flat) geometric layout, so that we can easily overlook their third dimension and only focus on their planimetric morphology and representation. No inferences, of course, could then be drawn out of the observation of such urban cases. Only orographically irregular settlements, densely provided with significantly steep paths, are therefore suitable as a reliable subject for studies on the matter: and,

Figure 1. The criterion for the introduction of mark points along the steep paths.



on this regard, Italian historic centres appear a wide and precious research field for such experimentations.
The method sketched above, and proposed as 3D Ma.P.P.A. (Buffoni, 2012), was applied to the case studies of Volterra, Massa Marittima and Siena in order to test its reliability and, even more, to compare the results with the outputs of the pre-existing techniques. As mentioned before, each of those settlements is strongly characterized by the frequent presence of steep paths, variously distributed along the respective whole grid. The results of the previous researches, carried out without taking into account the orography, were in all cases nearly outstanding, proving a narrow correlation of the actual density of activities with the distribution of integration. In fact, operating by axial analysis, and grouping the lines with reference to their integration value, in order to mitigate the likely effects of incidental or fortuitous elements on the trend of the distribution, the results show an exponential correlation, whose R2 values in Volterra, Massa Marittima and Siena all exceed 0.85; and similar values result from a similar grouped correlation following Ma.P.P.A..
In order to highlight the differences of the systems analysed

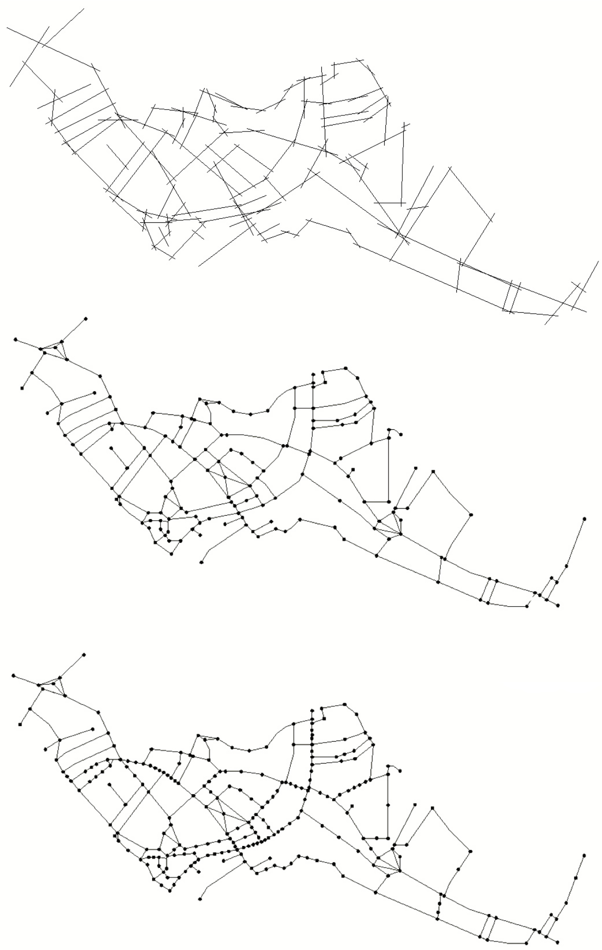


Figure 2. From above: the axial lines, the mark points and the 3D mark points correspondent to the grid of the historic centre of Volterra.

by the applied techniques, with reference to the grid of the historic centre of Volterra, in figure 2 the lines of the axial map, the mark points and the 3D mark points are respectively represented. The same maps are used in figure 3 to highlight the integration core, as it results from the analysis of the respective system. In figure 4 the exponential correlation of density of activities versus integration in the case studies of Volterra, Massa Marittima and Siena, as it respectively comes out of axial analysis, Ma.P.P.A. and 3D Ma.P.P.A., are represented. In table 1 their resulting R2 values are summed up for a prompt comparison. On this regard, a slight difference in the appraisal of the density D of activities (anyway assumed as an indicator of centrality) ought to be specified: in the first analysis, matched with axial integration, the density D is assumed as the density of activities along the line (number of activities per metre); in the other cases, matched with Ma.P.P.A. integration, the same parameter is assumed as the density of activities in the surroundings of the mark point (number of activities per square metre).

Figure 3. From above: the integration core of the historic centre of Volterra, as it results from axial analysis, Ma.P.P.A. and 3D Ma.P.P.A.

Such difference, although numerically remarkable, is likely not to affect the qualitative trend of the values and hence the significance of their comparison.

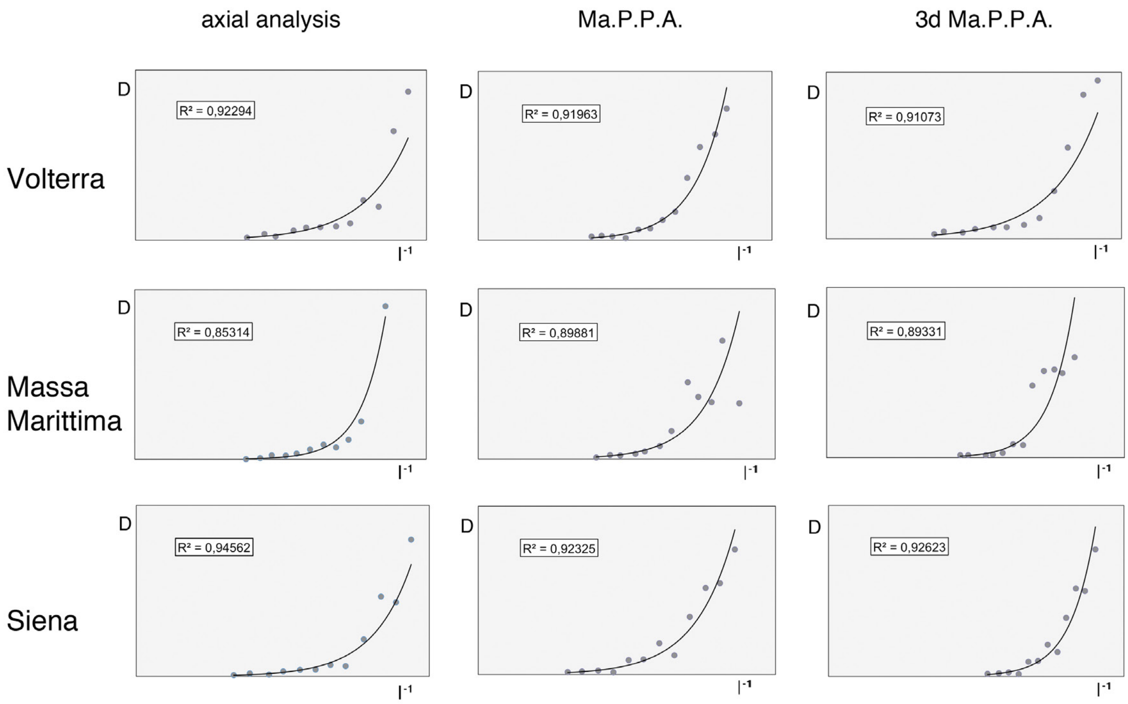
Methods	**Volterra**	**Massa Marittima**	**Siena**
Axial analysis	0.92	0.85	0.95
Ma.P.P.A.	0.92	0.90	0.92
3D Ma.P.P.A.	0.91	0.89	0.93

Table 1 - R2 values referred to the analysis of the correlation density of activities versus integration

The application of 3D Ma.P.P.A. to the selected case studies have thus provided results that hardly appear to improve those obtained by the existing – and previously tested - configurational techniques. In such sense, the expectations of a significant development of the configurational approach can be said disappointed. All the same, in this regard some remarks appear necessary.

First, it should be noted that the effectiveness of a method and its improvement with respect to the existing ones does not merely depend on the capability of providing results which (slightly) better approximate the actual consistency of a settlement: other aspects (the conceptual logic and the comprehensibility of the method, as well as its ease of use) ought to be taken into account. On such basis, the 3D Ma.P.P.A. has to be valued for its actual capability of appreciating also the altimetric dimension of the paths, and for doing it objectively and automatically, importing it from an existing territorial database.

Figure 4. The analysis of the correlation density of activities (D) versus integration (I-1) in Volterra, Massa Marittima and Siena, as it results from axial analysis, Ma.P.P.A. and 3D Ma.P.P.A.



Moreover, it's worth highlighting that the outcomes of the application of both axial analysis (Bortoli, Cutini, 2001) and Ma.P.P.A. (Cutini et al., 2004) were already so outstanding as to strongly certify the reliability of those methods as well as to demonstrate, more in general, the actual potential of the configurational approach. An improvement of such striking results could hardly be expected and, if obtained, would not be significant; nor, in concrete terms, some centesimal rise of R2 would justify the increase of the computational burden the new technique calls for, so as to assert some benefit in overtaking the existing ones.

Furthermore, the correlations of 2D Ma.P.P.A. and 3D Ma.P.P.A. integration versus activities appear so similarly narrow as to suggest that the three-dimensional extension of the method does not seem to provide a real enrichment of the existing results, as though the altimetric features of the grid were actually somehow embedded within its two-dimensional configurational variables.

In light of what we have shown so far, this discussion appears worth extending, in order to discuss the actual influence of the orographic trend in the configurational state of an urban grid and hence, more in general, the likely role of altimetry on the inner geography of urban centrality.

2. The results of the analysis

What was analytically investigated by means of the proposed method was also observed by an empiric approach, investigating on the correspondence between configuration and orography in a wide set of case studies: Arezzo, Cortona, Massa Marittima, Montalcino, S.Gimignano, Siena, Vinci and Volterra. All these cases, different each other on all regards, still share an unquestionable common denominator, that is their position on high and precipitous rises: just slope, meanly over 5%.

In such settlements, as discussed above, the steepness is obviously expected to play a role of deterrence towards the location of activities: in other words, central spaces (commonly defined as the most crowded with movement and activities) are therefore expected to be located along the flat paths, easier and more inviting, so as to reduce the actual spatial impedance; on the contrary, the steepest ones, so hard to go through, should likely be far more segregated and deserted. The study over our cases was aimed at verifying such an intuitive expectation, by means of the analysis of the correspondence on their grids of the levels of urban centrality (assumed in terms of attractiveness towards activities, resulting from the observed density of the existing ones) with the actual slope of the paths, as it results from its direct survey.

And the results were quite surprising, so as to turn round the above sketched expectations: in all cases the distribution of the density of activities does not correspond to the flatness level; on the contrary, and against any expected logic, flatness and attractiveness do actually appear negatively correlated, so as to show activities densely located along the steepest paths. Even more, in most cases the main urban street (that is the most crowded with shops, and offices, and people strolling, and urban life) just coincides with one of the steepest streets (when not just the steepest one), where, at a guess, shops, and offices, and strolling people and urban life should not be.

In Arezzo, Massa Marittima and Siena, people cheerfully climb over steep main streets, and there go for shopping, patronize the most prominent activities, go to the church, meet and relate each other, neglecting and leaving deserted most of the level streets. We could also add that those steep and crowded paths in all cases go and converge into the main wide open space of the grid, the "piazza grande" of the settlement, the public place that was recognized the suitable urban space for meeting, gathering and interaction (Cutini, 2003). In other words, far from discouraging movement (and hence the location of activities), the slope of the paths appears so as to attract it, and therefore to stimulate activities to locate in order to flourish, taking benefit from such a precious irrigation.

Can such a counter-intuitive phenomenon be regarded as casual or incidental, despite its regular confirmation in all the selected urban cases? Or, on the contrary, should we credit the slope with some attractiveness towards the pedestrian movement or towards the presence of urban activities, despite any behavioural logic? Or, what's our thesis, should we consider the inquired aspects (the presence of activities and the slope of the paths) both significantly correlated with the configuration of the urban grid? In such case, their mutual correspondence should be regarded as a logic consequence, rather than a singular fortuitous incident or an improbable deterministic effect. In other words, if centrality is assumed as a spatial process, primarily influenced by the grid configuration, it's worth discussing the role altimetry is likely to play in this process.

In order to verify this thesis, investigating the correspondence between configuration and centrality, as well as the correspondence between configuration and slope, the grid configuration of the selected case studies was analysed, so to obtain the distribution of integration values.

The result of the configurational analysis provides a strong confirmation to the prospected thesis. In all the selected cases, configuration and centrality (as reproduced by the actual presence of the located activities) appear narrowly correlated. Grouping the lines in 12 sets, in order to clean the distribution of integration from the effect of any incidental or local element, an exponential correlation emerges with R2 values always well over 0.75; in some cases (Massa Marittima, Siena, Volterra) the determination coefficient results over 0.90. As it can be argued, the exponential form of the relation can be easily referred to the multiplier effect the located activities are likely to play, attracting movement and then additional activities (Hillier et al., 1993). What confirms centrality as a function of configuration, also in steep settlements, and even analysing their grid according to a traditional three-dimensional approach.
The analysis was then oriented on the correspondence between configuration and orography, which was carried out on the same urban cases, studying the correlation of the integration value of the streets (more precisely, the corresponding lines) versus their mean slope. Again, referring to groups of streets, the presence of a correspondence was in most cases (7 on 8) certified by a significant R2 linear correlation coefficient. Furthermore, the study was extended over a wide set of smaller urban settlements arranged on top hills. In those settlements, at present actually lacking in economic activities, the analysis could not be addressed to the distribution of centrality but only onto the correlation of grid configuration with slope. And in all the additionally selected cases the results appear fully confirming our previous results: as a matter of fact, integration and slope go together, linked in most cases by a linear relation, attested by significant R2 coefficients.
Such a singular result deserves a brief discussion, in order to be accounted for. In general, we can't but notice that in orographically irregular settlements slope and integration are significantly related, so that the distribution of slope can, at some extent, reproduce the distribution of the levels of integration. Still, this correspondence involves another, quite singular, inference: slope and centrality, by means of their mutual relation with the grid configuration, result significantly correlated, so that in many cases the most central urban places are just the steepest paths. Such inference appears dramatically conflicting against the intuitive expectations sketched above on the relation between slope and attractiveness towards activities. In other words, configuration, as linked according to different relationships with slope and attractiveness, seems to play a role of go-

between with them: as linearly correlated with slope, it appears to attract activities towards the steepest paths, while common sense would suggest just the opposite effect.
A set of urban cases in Tuscany as well as in Southern Italy, selected among the others as easy samples, can be here presented as paradigmatic and discussed in order to account for this singular phenomenon.
First, the smallest urban case, the ancient village of Castiglione della Pescaia, erected in the XII century by the Republic of Pisa as a fortified military outpost on the Tyrrhenian Sea. The settlement, at present still encircled within its ancient town walls, lays on a high and steep hill over the coast line, with a difference in height of more than 50 metres, what drives the mean slope of its inner paths up to 15 %. The regression analysis of the correspondence between slope and integration shows a narrow correlation, attested by R2= 0.92. The steepest street (characterized by a mean slope value of 16 %) is the path that connect the entrance gate of the town walls (down the hill, on its eastern side) to the turreted castle (on the top of the hill, on its western one) and is also by far the main integrator; on the contrary, most of the other streets, which are studded with the largest part of the housing estates, lay almost flat, running as concentric crescents around the top of the hill, southbound to northbound parallel to its contour lines (figure 5). It's worth noticing that most of the houses, arranged parallel to the slope of the hill, present on their side downhill one more level than on the side uphill. Other steep paths (and among them some even provided with stairs) cross those level streets, and, offering the possibility of climbing the hill, gain a relevant integration value.
Drawing out some conclusions, it's possible to say that the village appears "naturally" arranged according to the contour lines of the hill, and that the paths which connect its lowest side to the top are disposed according the maximum slope direction, so as to correspond, orthogonally crossing all the other streets of the settlement, to the most integrated lines of the urban grid. Although in the XX century most of the economic activities of the settlement have been shifted outward to the suburbs, still it's easy to notice that all along the steepest path (that is also the prime integrator) we can recognize the presence of the aligned doors of pre-existing shops and stores, what is likely to indicate that route as the ancient main street, the most crowded and central path all over the village before its recent suburban development. When in the first decades of the XX century a suburban development has gone growing outwards, at the foot of the hill, again the prime integrator appears located as corresponding

to the streets which connected the recent, lower area to the ancient urban core, still encircled within the town walls; and again that street was one of the steepest paths of the whole settlement. Actually centrality hence appears as a process, depending on the relationship between the spatial elements of the grid; and, what is quite unexpected, in such a process it follows the urban developments remaining from time to time clung to its steepest paths.

As a further example, the urban core of Manciano, raised in the XIV century as a feudal settlement around a castle on the top of a high rise in the inland of southern Tuscany, presents similar features. Again, the study of the correlation between slope and integration has provided outstanding results, with R2= 0.90. And also in the case of Manciano it is possible to recognize the distribution of the larger part of buildings along a sequence of flat streets that revolve around the castle following the contour lines of the hill, and a minor part of streets that connect the lower areas, near the gates of the town walls, to the higher ones, surrounding the castle on the top of the hill. Also in this case the level streets are provided with low values of integration, while the integration core of the grid coincides with the radial (and steeper) ones (figure 6). Again, the ancient dense presence of shops and stores can be easily retraced in the lots of doors, gates and windows that, now closed, still appear lined up along the steepest path of the settlement (its main integrator); on the contrary, the level paths which run parallel to the contour lines of the hill are outlined by merely residential estates, whose windows overlook the flat country downhill. And again, as recent development areas have gone growing around the town walls, the integration core of the grid has gone shifting out of their perimeter, presenting the prime integrator in the steep path connecting the lower, recent suburbs to the ancient town, that at present can actually be recognised as the main street of the settlement.

Two small urban settlements in Southern Italy can be presented as paradigmatic case studies (figure 7).

The village of Rocca Imperiale, near the Ionic coast of Calabria, confirms the results of the analysis of Castiglione

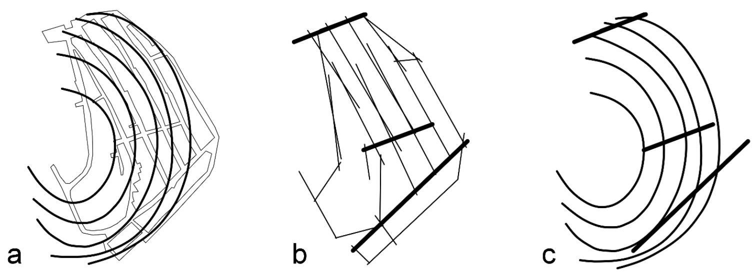


Figure 5. The grid of Castiglione della Pescaia (a) and its integration core (b, c).

della Pescaia and Manciano, with a narrow correlation (R2= 0.82) between slope and integration (figure 8).
Very interesting is also the case of Positano, a well-known touristic village in the Sorrento peninsula, near Naples. This small urban settlement develops from the bottom to the top, since the most densely populated areas are located close to the coast, while the access is provided on the top, from a panoramic road located halfway up the hilly landscape of the area, with an overall height difference over 250 m. If the resulting spatial working is therefore overturned with respect to the other presented cases, nonetheless also in this case the correlation between slope and integration is particularly significant, with R2= 0.68 (figure 9), confirming a narrow relationship between spatial layout, urban morphology and centrality.
The same relationship can be traced in the grid of larger urban settlements, provided they are characterized by the irregular orographic profile of the ground. If we observe, for example, the configurational values in the city of Naples, we can notice a clear correspondence between its integration core - 4% of the most integrated lines - and the distribution of the steepest streets: here, if we only exclude the promenade paths, the urban structure of the ancient city, so fundamental for the entire city (Di Pinto, 2018), has developed nearly transversely to the contour lines (figure 10), contributing to the well-known pattern of Naples as a city that "goes" from the hills to the sea, rather than that of a city "enclosed" by the hills.
Summing all up, the presented case studies provide several common elements that seem to point out a generative process as follows: the spatial need of connecting the urban areas at the foot of the hill to those at the top hill recurrently determines some connection paths which are both among the steepest and the most integrated spaces of the settlement. This is why natural movement influences land use pattern by attracting movement-seeking activities just along the steepest paths and relegating the residences into the flat spaces.
In other words, once more (Hillier, 1999b) nonlocal properties of elements (relations) appear to attract movement

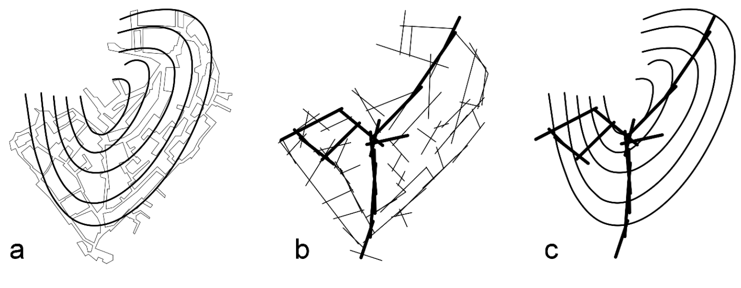


Figure 6. The grid of Manciano (a) and its integration core (b, c)

and, through it, the location of activities; while the intrinsic (geometric) properties of the grid, as altitude and slope, remain internalized within its configurational variables. It is then the relations what drives the distribution of activities and land uses, while geometry provides the material shape of the settlement. In the observed settements the geometric layout, under the guise of altimetry, is not the mere result of arrangement solutions, but a precondition in the utilization of ground. And the grid configuration reproduces the way the settlement fits into the site, in such a way that that the relationships between the parts of the settlement make possible and efficient its actual use.
What was sketched above appears to assign the grid of the paths of a settlement the role of interface and link between geography and land use. The function of the urban grid, as it results from a configurational approach, was squarely hit defining it as “a mechanism for generating contact” (Hillier, 1996b); now such role is confirmed and even broadened, highlighting the grid as the very intermediary between the

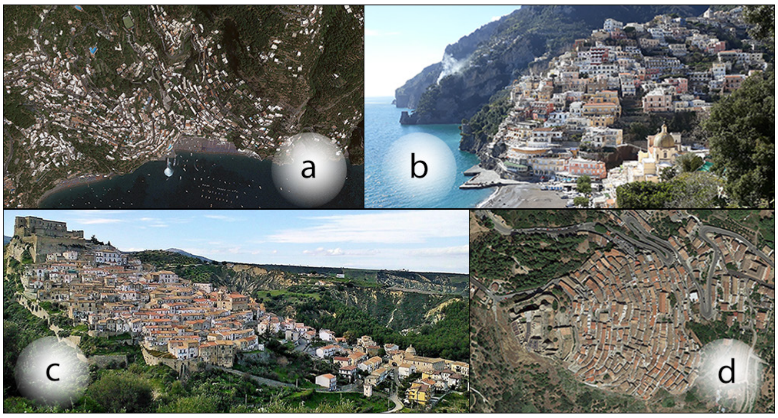


Figure 7. The urban centres of Positano (subfigures a and b) and Rocca Imperiale (subfigures c and d): aerial photography and panorama.

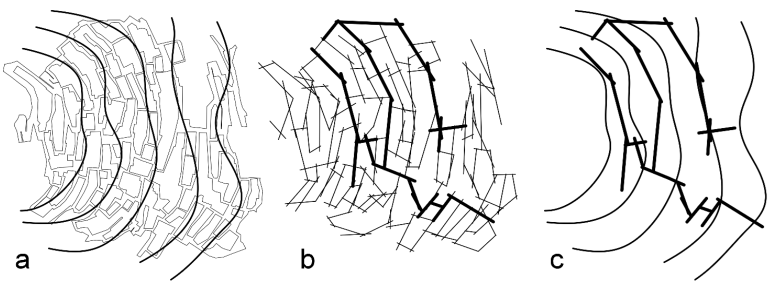


Figure 8. The grid of Rocca Imperiale (a) and its integration core (b, c)

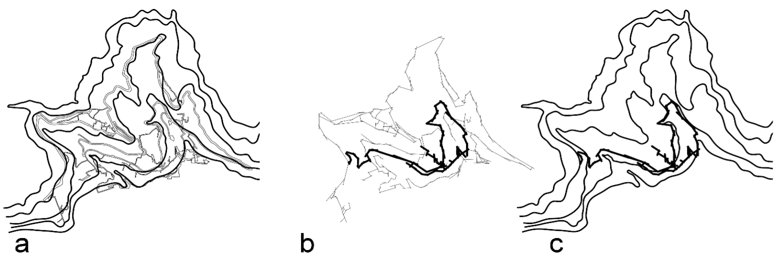


Figure 9. The grid of Positano (a) and its integration core (b, c)

place (with its material and geometric features, and orography above all) and the functions that are at being arranged over it.

Conclusions

Hereinafter some conclusions can be easily drawn out of the results so far. First (and most obvious): morphology and configuration are undoubtedly linked, in that the way the blocks of buildings are singularly shaped, disposed and aligned within a whole settlement, as well as the way the paths are arranged in order to brush and connect all them, does certainly influence the distribution of the configurational indices. And in such arrangement the orography of the site represents a fundamental variable, so as to determine the recurrence of common solutions in the process of urban genesis and development and the appearance of some typical configurational patterns. The configurational pattern, in its turn, determines typical and recurring effects in land use and in particular in the distribution of urban centrality, which appears shifting as the settlements goes expanding and developing.
Second (and less obvious): orography does matter, though not according to the traditional appreciation and intuitive expectation, which regard spatial impedance as a function of slope, positively correlated with its values: orography does matter in that it influences the arrangement of urban space, and then the configuration of its grid. In some cases (those here summarized), such influence can ever determine the strong attractiveness of the steepest paths and the segregation of the flattest ones. In such sense, the orographic features of a settlement are internalized within the variables that represent the configurational state of the system.
Third (and least obvious): not only does integration, hence, reproduce the internal geography of an urban settlement with regard to the distribution of activities and land use, that's to say the way that settlement is used. It can also describe (roughly but consistently and reliably) the way an urban settlement fits the specific orographic condition of its site, that's to say the way that use is actually made possible in the local geographic context.

Figure 10. The grid of Naples (a) and its integration core (b, c)

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