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HOW DID THE WHOLENESS OF BEYAZIT SQUARE CHANGE IN THE LAST SIXTY YEARS?

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Abstract. Starting from the nearest proximity, there is a hierarchy of size, scale and shapes among the built elements that embodies a sense of wholeness radiated through. This research focuses on the question of how to measure this kind of wholeness across scales. Methodology developed for this question combines C. Alexander's Theory of Wholeness with C. Shannon's Information Entropy. The algorithm translates various morphologic possibilities into digitized data, entropy-iqr, out of building footprints images. Total sum of entropy-iqr values have been hypothesized to correlate to the degree of wholeness for the analysed scales. Analyses conducted upon the data of 1946 and 2013 for Beyazit Square in Istanbul Peninsula reveals that the cumulative wholeness of the square has been deteriorated from 0,32bit to 0,63bit in the last sixty years. This finding is being verified by the remarks of the spatial assessments done for the square and visualized by deformed grids through the entropic interaction way of spatial modelling. The method, as a novelty, shifts measuring relative state of wholeness of built environment from intuitive to a data-driven basis.

Keywords. Wholeness; Completeness; Entropy; Change; Modelling

1. Introduction

Alexander's overall idea of wholeness and life stands on a strong basis of completeness. The wholeness of a system is not about the quality and behaviour of each single entity what he calls "centre", but the way they come together and make each other strong across scales (Alexander, 2002-2005, p. 144). This implies an emerging sense of wholeness about the relative size, shape and density of centres. Leibovici (2009) in this respect notes that there is still a need for a coherent methodological approach that will consider the relatedness of constituting elements as an adjacency factor among multivariate spatial data.

This study raises the question of whether or not we can scientifically measure Alexander's definition of wholeness or completeness using "Levels of Scale" property of wholeness (Alexander, 2002-2005) in cooperation with "Shannon's Entropy" (Shannon, 1948) theory. The role of the scale levels in such information retrieval process is to set a dynamic grid interface upon the analysed area's building footprints raw data. Size of the grid cells are dependent on the number of pixels that are framed for each scale level as seen in Figure 1 below.

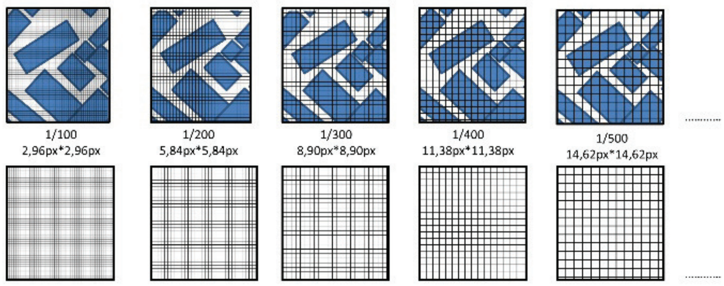

Figure 1: Scaling the Grid via Changing the Scale Level and Thus Number of the Pixels Framed by Each Grid Cell

2. Dataset and Method

In order to examine the spatial disorder and entropy, a spatial analysis tool has been developed by using two major programming languages; "C#" by Microsoft (2015) for data-mining, and "Processing" by Ben Fry and Casey Reas (Jones, 2010) for data-visualization. The tool developed for this research enables running the analyses for various scale levels. This leads to a highly varied data with deviations. The multivariate nature of the data requires a discretization to eliminate the divergences in order to measure it. IQR (Interquartile Range), a statistical data measuring method, does a discretization for the data with varying spreads to eliminate the extremes of the data and reduce to a single value as seen in Figure 2 below.

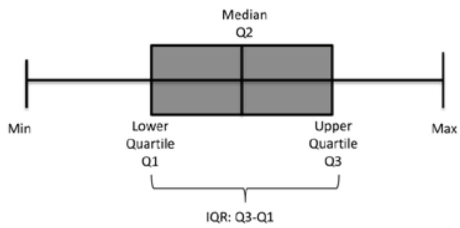

Figure 2: Generating the IQR Values

Referring to Shannon's entropy as formulated in below Equations 1, 2 and 3, for the i^{th} cell of n celled grid system, Gi is the cell specific built portion where Pi value, considering the eight adjacent neighbour cells' G values, is a relative value considering the adjacent cells. Hi is the entropy for the i^{th} cell and it is calculated as long as the cell is adjacent to eight surrounding cells as seen in Figure 3 below.

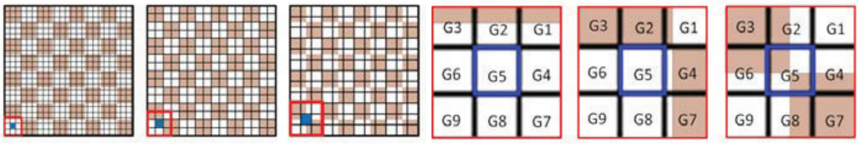

Figure 3: Cell Positions and Their Interactions with Immediate Neighbours as Adjacency Factor in Calculation of G, P and H Values

$$G_i = \frac{Built\ portion\ of\ pixel\ i}{Total\ pixel\ area} \qquad (1)$$

$$P_i = G_i / \sum_i^l G_i \qquad (2)$$

$$H_i = P_i \cdot \log(\frac{1}{P_i}) \qquad (3)$$

Equations 1, 2 and 3: G, P and H Calculations

Each grid cell as seen in Figure 3, matches a particular space and thus a particular portion of morphologic probability represented by a G value. Algorithm assigns G=0 when the cell area is totally unbuilt and G=1 when it is fully built up.

2.1. Beyazit Square and its evolution

Scholars (Ayvazoglu, 2012), (Müller-Wiener, 2002), (Eyice & Kuban, 1993) note that the most destructive intervention upon one of the most historic and symbolic squares of Istanbul Peninsula occurred in 1950s due to the Prost plan, which gave priority to the motor-vehicle traffic. Spatial assessments (IMM, 2012), (Protection Board for Cultural Assets, 2013) both point out to the poor spatial quality of the square due to remarkable change within the last decades. As shown in Figure 5, a 50 hectares = 500.000 m2 built area as two .tiff images 1024x1024 pixels each that belong to two different time periods, 1946 and 2013, has been selected for the comparative analysis.

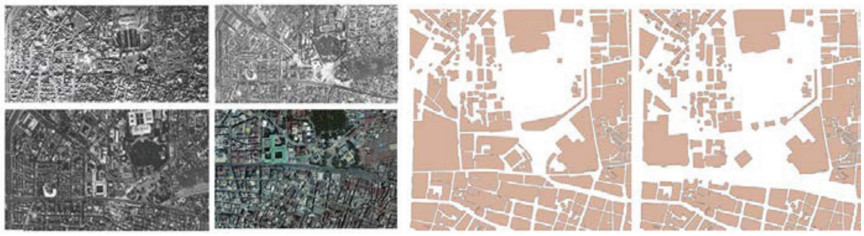

Figure 4: Left 4: Satellite Images: Beyazit Square and Environs in 1946(Upper-left), 1966(Upper-right), 1982(Lower-left) and 2013(Lower-right) (IMM, 2012). & Right 2: Building Footprints: 50 hectares Beyazit Square and Environs in 1946(Left) and in 2013(Right).

3. Results

Multi-scalar analyses, as shown in the graphs in below Figure 5, revealed that the change with the cumulative entropic state has deteriorated, almost halved, from 0,32bit to 0,63bit entropy level.

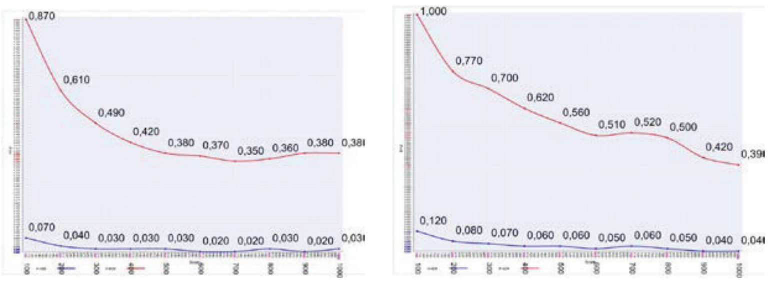

Figure 5: Multi-Level Analysis and G-IQR (Red) and H-IQR(Blue) Results For a) 1946(Left) and b) 2013 (Right) Data

3.1. Modelling the entropic interaction

Higher entropy means higher tendency towards uncertainty. From the spatial relatedness point view, a built area framed by a cell unit is spatially and geographically related with its interacting neighbour cells and intrinsically through each other's entropic states. In other words, there is a constant interaction among the system parts. This can be visualized by a mutual effect interaction modelling, displacement of the four vertices of each cell due to cell-specific entropy values as explained in Figures 6 a,b,c,d, and e below.

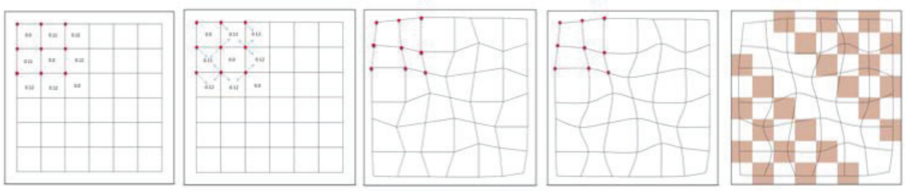

Figure 6: Visualization of the Entropic Interaction throughout a Grid System (Left to Right a, b, c, d, e)

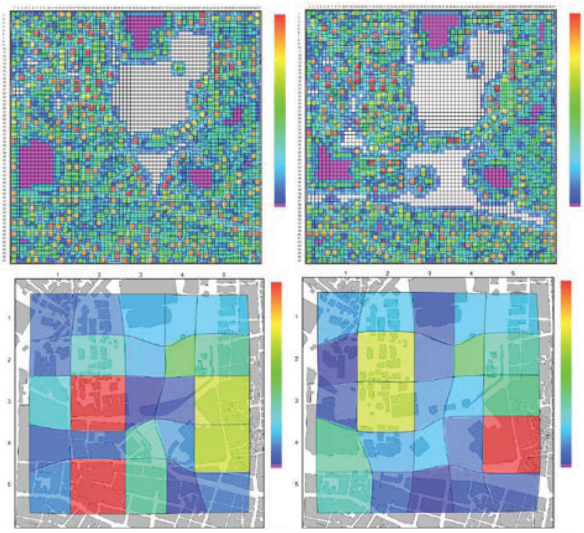

Figure 7: 100 (Upper two) and 1000(Lower two) Grid Levels Entropic Interaction Modelling Visuals For 1946(Left column) and 2013(Right column) Morphologic States

Entopic interaction way of data modelling for 2013, when comparing to 1946 deformed grids, for 100 and 1000 pixel levels, as seen in Figure 7, shows that the changing topologic state is leading to higher deformation in the west, south west and south cell regions.

4. Conclusions

Spatial evolution or change, with an increasing trend, has been studied through diverse map-comparison technics in which both traditional and advanced techniques have been incorporated for various purposes such as detecting temporal/spatial change, comparing different models or scenarios, or for calibrating/validating land use models (Visser & de Nijs, 2006). The novelty and originality that proposed method introduces is that it measures space through notion of spatial relatedness which morphologically and intuitively radiates a relative degree of wholeness. Such wholeness more than being context dependent, is highly about the level of investigation since the system continually redefines its entropy as the morphologic interplay among the adjacent grid cells changes. The results in this study show that the cumulative degree of wholeness of the square significantly decreased within last sixty years and it is being verified by the remarks of the spatial assessments

(IMM, 2012), (Protection Board, 2013). Finding proves that in spatial terms, there are a lot of degrees between dead and alive. This methodology proposal, as an evidence-based spatial analysis approach, generates the entropy levels through the missing information of varying morpho-information levels. The method, for micro spaces such as Beyazit Square case, gives reliable results. However considering that wholeness is a broad and not so clear term attached to various spatial, functional and contextual dynamics, the outcomes relying on pure topologic input may not suggest benchmark results on complete understanding of wholeness but a data-driven scientific approach for evidence-based measuring of spatial change scenarios for legible and perceivable built environments.

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