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Research Article

Use of GLCM Entropy Parameter in the Analysis of Urban Function Spaces; Antalya City Example

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Abstract

Urban spaces are concentrated in certain functions to meet the needs and desires of the urbanites. However, for each city, different functions and the value of the space to meet these functions are different. In this study, spatial entropy analysis of Antalya, the most important tourism city of our country, was carried out through GLCM Entropy analysis, one of the texture parameter methods. In the study, firstly, function areas and function spaces were determined. A 5-meter resolution Esri Satellite Image for 2022 was obtained to perform texture parameter analyses. The satellite image was scaled to include the whole city and urban spaces with QGIS software, and then the general entropy values of the city were calculated with Definies software. Then, selected urban spaces with different functions were extracted from the satellite image and subjected to entropy analyses. According to the results obtained, the areas with the highest entropy difference for Antalya city were determined as airport and seaport, which are transportation and trade places. For Antalya, which has poor road access to the world due to geographical reasons, it is seen as an important determination in terms of analysis that the places representing air and sea connection come to the fore.

Keywords: Urban space, entropy, remote sensing, texture parameter.

Introduction

Cities, the symbol of civilization, are among the most important traces left by humanity to the world. Man's ability to design and build is embodied in cities. Just as the atmosphere of nature is dominant in the countryside, the influence of human beings is as intense in cities. In a way, cities are the manifestation of man's desire to get rid of the sovereignty of nature and gain his own control. Humans have achieved this control by organizing the environment and building structures, that is, by creating urban spaces. Along with humans, cities and the urban spaces that make up them have undergone continuous changes in form, meaning and function from the first examples to the present day. The social, cultural, political and economic structure of their period has shaped the character of cities (Karakurt, 2006; Rasmussen, 1969). In this way, urban spaces such as Roman baths, medieval city walls, Baroque boulevards, Turkish-Islamic masjids or modern-day shopping malls have emerged. Of course, the distinct urban space and the changes in it are not only formal but also affect human behavior and urban functioning. For example, the wide avenues of post-Hausmann Paris gave rise to café life and a boulevard culture (Gehl, 2020).

Although the history of cities for humanity dates back to 3500 BC, today's modern urban appearance began to emerge after the 18th century. Especially the industrial revolution can be considered a turning point in terms of urban history. The concentration of factories with the industrial revolution encouraged migration to cities and led to an extraordinary increase in the urban population. The urban population, which was one tenth of the rural population until this period, started to increase gradually. The process that started in Europe spread over time and led to the growth of cities around the world. Not only has the population of cities increased, but modern urban needs and outlooks have also become apparent. The addition of globalization to industrialization after the Second World War was another factor that accelerated this process. Today, for the first time in history, more than half of the world's population lives in cities. A significant portion of them live in metropolises that have emerged in modern times (Duman and Bilgili, 2022; Gehl, 2020).

Industrialization and subsequent globalization is a process with sociological, economic and cultural aspects and has a wide range of effects. Cities are undoubtedly one of the most affected places. Globalization has not only increased the number of cities and urban population, but has also changed the perception of the global city. It has caused noticeable developments especially in urban spaces (Beyazıt and Güneş, 2020; Ökmen and Parlak, 2008). Today, cities have entered into competition with each other in order to gain a place in the modern world and attract global capital. In line with this competition, cities are being restructured and strive to become globally important business and living centers. In order to be successful, the city needs to build an identity with the features it has or will add. Urban appearance and spatial structure are of great importance for a good city image (Budak and Kavanoz, 2019;

Tümtaş and Ergun, 2016). After industry and globalization, cities have started to offer uniform landscapes. Although cultural differences are still effective, similar cities and urban spaces are now seen all over the world (Belge, 2018). This situation is related to people's perception of the global city and the sameness of what they expect from the city. Thanks to similar perceptions, cities consisting of shopping malls with the same restaurants and stores are emerging. Especially with the impact of tourism, the urban space is recreated through certain images and similar areas are created to provide more touristic attraction. However, in order to create the desired healthy spaces, good planning should be done and structures suitable for the physical and human conditions of the city should be created. In this case, it becomes important for the city to have visual and numerical information of the space within a certain power (Budak and Kavanoz, 2019; Judd and Fainstein, 1999; Pender and Sharpley, 2005; Sarı and Türk, 2021).

All cities are characterized by harmony and disorder. As a complex system composed of many different elements, the most important components of cities are society and space. Society builds places on geographical space (Cabral, et al., 2013). Each space is created by enclosing a certain physical area with some materials depending on the construction technique of the era in order to meet a certain need of the society (Altan, 1993). In order to respond to the needs of the society, it fulfills functions that correspond to certain services. Urban functions are categorized as general and special; military, religious, educational, economic, legal, administrative, cultural, health, industrial, art, sports, commercial, tourism, transportation, *etc*. (Bayartan, 2007). All functional spaces, natural or artificial, have a value within the city. This value is related to the function that the space fulfills as well as its location, shape, size, purpose and priorities of use. As the meanings and functions of the parts of space diversify, multidimensional research is required to understand the urban structure, which has become a knot of relationships, but there are few methods that can establish such urban space connections (Ratti and Richens, 1999; Salihoğlu, 2020). Generally, studies that focus on a single space are not sufficient to understand the value of space in the city. For this, it is necessary to evaluate the space within a city view with a part-whole understanding.

One of the first concepts that comes to mind in the research on the relationship between the part and the whole is entropy. Although entropy is known as the expression of disorder, in reality it is a measure of the tendency to be disordered and the combinations that can occur in the transition of regularity to disorder. According to entropy, the Second Law of Thermodynamics, disorder in the universe tends to increase continuously and everything tends to pull itself towards minimum energy and consequently maximum disorder. The fact that the items on a table tend to be constantly scattered, tend towards maximum disorder and the items are scattered differently each time is an example of the entropy law (Bostancı and Ocakçı, 2009; Marchettini, et al., 2006).

Entropy, which is handled by almost all branches of science, is also used in urban studies. GIS and remote sensing technologies developed in recent years have paved the way for the inclusion of entropy in urban analysis. In urban studies, entropy applications have been frequently used especially in urban morphology, urban sprawl and transportation networks. In these studies, all or part of a city spot or road pattern is usually selected on a satellite image and subjected to progressive entropy calculations. These analyses provide highly efficient and precise results, allowing urban phenomena to be solved analytically (Coutrot et al., 2022; Gudmundsson and Mohajeri, 2013; Öztürk, 2017; Tang, et al.,2018; Verzosa and Gonzalez, 2010; Yeh and Li, 2001). Despite these studies, most of the existing entropy measurements in the urban context are not spatial and do not represent the macroscopic state of the city. Spatial entropy, first studied by Michael Batty in 1974, has been applied to the study of population-based density and distribution in cities such as Los Angeles, London and New York. The study found that urban problems can be solved on a spatial basis (Barner et al., 2017; Batty, 1974; Ölmez, 2021; Purvis, et al., 2019). In current spatial entropy studies, land classification, sustainability, and density analyses are generally conducted (Chen, et al., 2017; Li and Claramunt, 2006; Wang and Zhao, 2018). Nevertheless, in urban studies, there is a limited number of studies that examine the effect of an urban space or image on the whole city, as opposed to entropy analyses that frequently address the effect of the part on the whole in other disciplines (Kapur, et al.,1985; Shiozaki, 1986). In order to understand the macro-level appearance of cities consisting of micro-components that interact with each other, the parts should be considered as a whole and their structural and dynamic characteristics should be analyzed (Marchettini et al., 2006; Ölmez, 2021). Our study will be one of the first examples of this applied to the modern cityscape.

The entropy approach in the analysis of urban space gives the study a numerical and technical quality and enables the solution of difficult to predict phenomena. The relationship between the spatial elements of the city and the holistic order of the city is revealed with mathematical expressions (Ekinoglu, et al., 2017; Konuk, 1992). Considering entropy from a spatial perspective will contribute to understanding circular flows within the city, using existing resources more efficiently and designing sustainable cities (Rondinel-Oviedo and Keena, 2023).

In our study, we tried to analyze the functional spaces of Antalya, the most important tourism city of our country, and to determine their impact on urban integrity by using the GLCM entropy algorithm. Antalya, which has become one of the world's leading tourism destinations, is visited by more than 15 million foreign tourists annually. The settlement, which consisted of a small castle and its surroundings in the early years of the

Republic, has spread over a very large area since the 1980s and has reached a population of 1.5 million todays. Understanding the dynamics, strengths and weaknesses of such a rapidly growing city will provide an accurate perspective for planning its future. Spatially based entropy analysis, as a different method, will help to illuminate the aspects that have not been possible to identify until now.

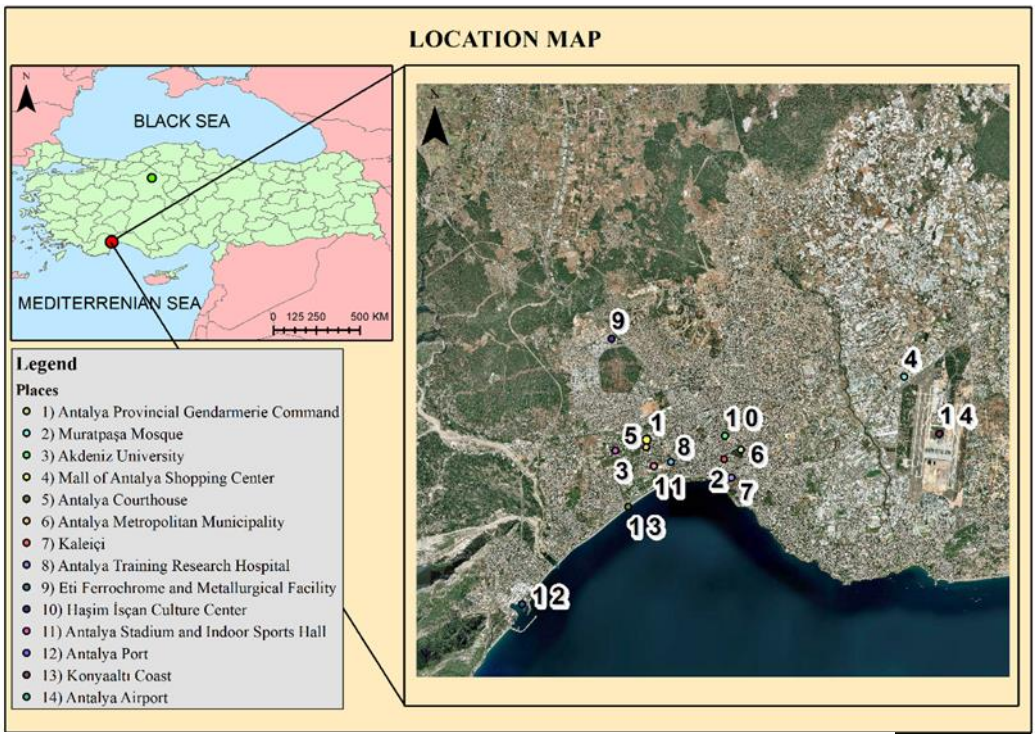

Fig. 1. Location Map

Materials and Methods

In this study, the GLCM entropy algorithm, one of the texture parameter applications, was used to analyze the satellite image of Antalya city spot and the entropy values of different functional spaces were determined. The starting point of the study was the question "Can the harmony, impact and importance of function spaces with different functions known to everyone in the city be determined numerically?". In this direction, first of all, the function spaces expected to be in a city were determined within the literature review. In the next stage, the method that will meet our problem question was tried to be determined and the GLCM Entropy algorithm was decided among the texture parameter analyzes. At this stage, it was thought that image analysis, which has been previously applied in many different fields of science, would be the most objective method and the entropy algorithm would reveal the relationships between the part and the whole. The necessary formulas and process steps related to the method are discussed in the next section and the visual and statistical results are explained. Antalya city, which has many different urban components and where we will not have problems in terms of accessibility and data supply, was preferred as the study area. Functional spaces in the city of Antalya were identified in accordance with the criteria. At this stage, we tried to select the most prominent examples in terms of size, use and quality (Figure 1).

Then, the satellite image required for the analysis was obtained. The selected image was provided via Esri Satellite Image with 5 m. resolution and 3 band color. The resolution of the image allows details to be seen clearly. The image was scaled and turned into a complete square that will include the city spot. However, for the next step, each location was cut out one by one from the satellite image. Then, the necessary normalizations were made in the Definies program and the texture parameter was analyzed in accordance with the GLCM entropy formula (Figure 2).

Texture Parameter

Texture is one of the key features used to identify objects or regions of interest in any aerial photograph, satellite image or micro-photograph. Texture is in fact an innate quality of almost all surfaces and contains important information about the structural arrangement of surfaces and their relationship to the surrounding environment (Haralick et al., 1973). In an image, texture is a representation of the spatial distribution of the gray level values of the pixels in relation to each other. The quality of the texture in the image to be applied is related to the scale of the study and the resolution of the image used. Texture, which offers the opportunity to be used in many different fields, and the parameters used with it help to obtain high quality precise results and to identify objects in the relevant image (Haralick, 1979; Özen and Aptoula, 2016). Texture analysis enables the pixel-based statistical evaluation of the spectral information in the related image object with remote sensing techniques.

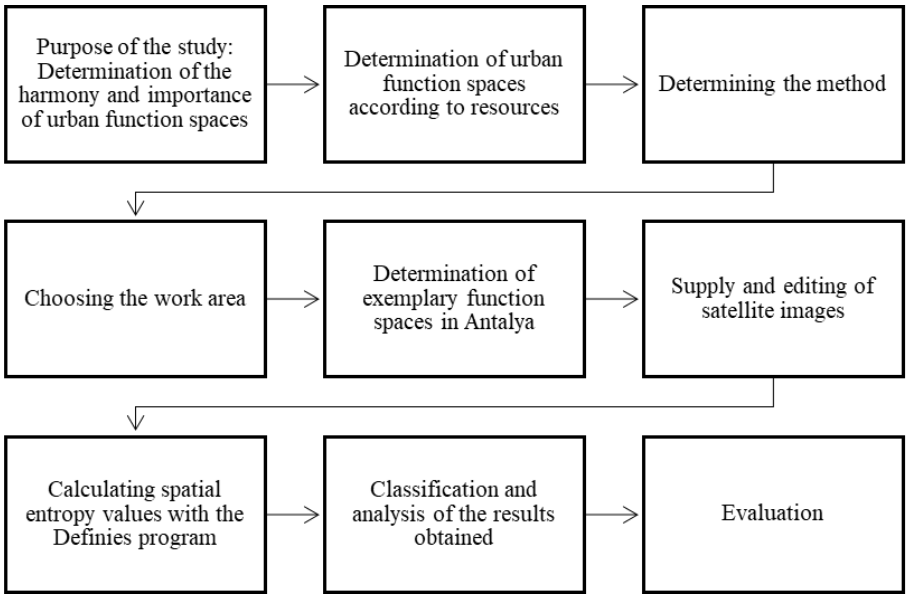

Fig. 2. Workflow diagram

Gray Level Co-occurrence Matrix (GLCM)

In most image analysis applications, basic statistics such as average, contrast, and kurtosis are obtained. However, these applications contain individual pixel values and cannot display connections between pixels. This makes them unable to provide sufficient results to provide a spatial analysis. However, the texture parameter analyzes introduced by Haralick allow the calculation of pixel connections (Löfstedt, et al., 2019). Texture parameters provide information about the spatial distribution of tonal variation in a band of the image. More precisely, it evaluates the connections between the color levels in the image together with the neighboring cells. Gray Level Co-Occurrence Matrix (GLCM) is one of the most common and accurate methods for texture analysis. It expresses the features of the entire image or the desired part of the image with combinations of gray level changes. GLCM expresses the relationship between two neighboring pixels. The first of these pixels is known as the reference pixel and the second is known as the neighbor pixel. Properties such as energy, entropy, contrast, also known as quadratic statistics obtained using GLCM were defined by Haralick and are used in applications such as image classification and segmentation (Acar and Özerdem, 2012; Baraldi and Panniggiani, 1995; Beliakov, et al., 2008; Demirhan and Güler, 2010; Horng, 2003; Hu, et al., 2008; Ölmez, 2021; Zaim, et al., 2006).

GLCM algorithms are considered as a holistic classification application. The GLCM method is based on a second-order composite probability density function. In the method expressed by the formula P(i, j | d, θ); i and j values indicate the displacement of image pixel gray values from i to j or j to i, while d corresponds to distance and θ corresponds to angle (Figure 3) (Ölmez, 2021). By adopting a square pixel-based system as a matrix system, Haralick (1973) defined the textural information on the co-occurrence matrix of N x N size. Today's remote sensing technologies allow the interpretation of urban texture through pixels (Ölmez, 2021; Pesaresi, 2000; Ratti and Richens, 1999).
In order to ensure that the textural features in the image do not change, one by one calculations are performed at θ = 0°, 45°, 90° and 135° to ensure the validity of the analysis and averaged for a fixed value (Figure 4).

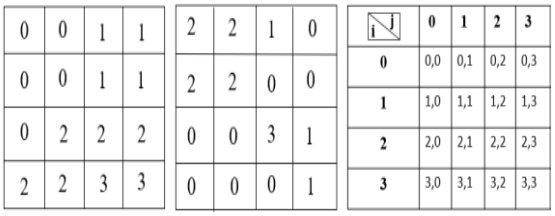

Fig. 3. Combination of GLCM image pixel values;
a) original appearance b) transformed view
c) combination of reference and neighboring pixel values (i; row j; column)

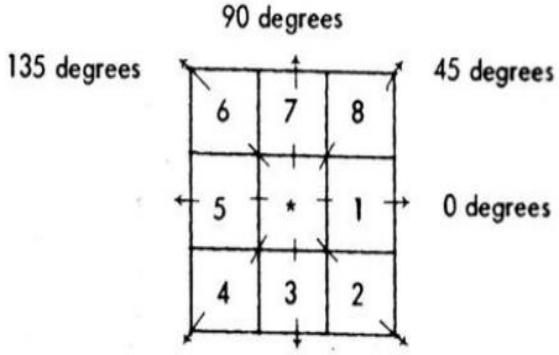

Fig. 4. Gray Level Co-occurrence Matrix (Haralick, Shanmugam, & Dinstein, 1973)

Spatial Analysis Application with GLCM Entropy

In GLCM applications, there are certain parameters to reveal the properties of the image texture. GLCM contrast, energy, correlation, mean, homogeneity, standard deviation, dissimilarity and entropy are some of them. GLCM correlation detects the connection of gray level values in the image with neighboring pixels. GLCM homogeneity is applied to detect areas where gray color levels in the image are homogeneously and heterogeneously distributed. GLCM contrast is the expression of heterogeneity in the image and is a measure of diversity, that is, gray level differences. GLCM standard deviation is a method for expressing the combination of the spread of matrix values within the image. GLCM energy is a measure of the repetitive transition between pairs of cells. GLCM mean corresponds to the average of the GLCM values in the image and is evaluated according to the combination of the pixel values in the image with other neighboring pixels. GLCM dissimilarity; Although it is similar in meaning to the concept of contrast, it corresponds to the expression of regional change rates of GLCM values. GLCM entropy is a parameter that shows the amount of information in the image and is also used as a measure of the randomness in the image. If the texture features of the image to be used in the analysis do not express uniformity and the GLCM values are evenly distributed, this corresponds to a high entropy value. Otherwise, the entropy value decreases (Alparslan, Aydöner, et al., 2004; Çalışkan, Emrullah, and Yılmaz, 2012; Demirhan and Güler, 2010; Ölmez, 2021; Sathyamoorthy, 2013). In our study, GLCM Entropy algorithm was preferred in the analysis of Antalya city function spaces. The reason for this is to understand the effect of the spaces within the city on the city in general. Our aim is to numerically express the effect of the pixel distribution of the selected objects in the image on the whole image. With this algorithm, which works according to the part-whole effect reflection value logic, the importance of the selected spatial elements of the city for the city was evaluated by obtaining numerical results. There are 14 function spaces selected for the study. These are the prominent areas of the city with different functions. The functions identified are military, religious, educational, economic, legal, administrative, cultural, health, industrial, art, sports, touristic, commercial and transportation (Table 1).

Table 1. Function spaces selected according to their features

Function	Type Selected Sample	Field Features
Military	Provincial Gendarmerie Command	Antalya is not a city that stands out with its military identity. The most important military area in the city is the Provincial Gendarmerie Command. It is located side by side with the university and the courthouse. It has an area of nearly 40,000 m².
Religious	Muratpaşa Mosque	It was built in 1570. It is one of the oldest Ottoman works found in Antalya. It has an area of approximately 7,300 m² including its garden.
Education	Akdeniz University	Akdeniz University is the first university in Antalya, founded in 1982. The central campus has a land surface area of 3,483,589 m² and a building area of 615,105 m². There are 24 faculties, 7 institutes, 1 conservatory, 12 vocational schools.
Economic	Mall Of Antalya Shooping Center	It is known as the largest shopping mall in the Mediterranean and Antalya. It has an area of 131,000 m². There are over 200 stores. It also appeals to foreign visitors with its proximity to the airport.
Law	Antalya Courthouse	Antalya Courthouse is the most important judicial institution of the province. The building has 8 floors, including the basement, and has a closed area of 73,000 m². The province's high court cases are heard here.
Administrative	Antalya Metropolitan Municipality	It is the local government mechanism of the city of Antalya. Local decision-making processes regarding the city are carried out by the institution. The mayoral building is located in the city center. It has an area of 15,000 m².
Cultural	Kaleiçi	It is the oldest residential core and heart of the city of Antalya. Together with its marina, it is now the cultural and historical center of Antalya. It is considered as a total area of approximately 450,000 m².
Health	Antalya Training Research Hospital	It is currently the most important health institution in the city. The complex, which includes all units, is highly preferred by citizens. The hospital has an open area of 16,532 m² and a closed area of 93,882 m².
Industry	Eti Ferrochrome and Metallurgical Facility	Founded in 1958, the factory is one of the oldest industrial facilities in Antalya. It was built on 338,260 m² of land. Low carbon ferrochrome is produced.
Art	Haşim İşçan Culture Center	It is one of the most important social and cultural activity areas of Antalya. In the center, plays of the State Theater and the State Opera and Ballet are performed. It occupies around 10,000 m² including the surrounding area.
Sport	Antalya Stadium and Indoor Sports Hall	The Stadium with a capacity of 33 thousand people and the Indoor Sports Hall with a capacity of 10 thousand people are complexes located side by side where sports activities are carried out in Antalya. The two complexes cover a total area of nearly 200,000 m².
Commercial	Antalya Seaport	Antalya trade port is the center of the city's foreign trade. The port area is 201,125 m², but the entire area reaches 2.5 million m². It has an annual handling capacity of 350,000 containers and 4,000,000 tons of dry cargo.
Tourism	Konyaaltı Coast	It is one of the two important beaches of Antalya city. It is 7 km long. Together with the Sahilpark project, it constitutes one of the most important touristic spots of Antalya.
Transportation	Antalya Airport	It has a total area of 13 million m² with all its borders and is the largest among the locations we chose. It became the second airport with the highest number of passengers in Turkey with 31.210.119 people in 2022. More than 25 million of these passengers are international flights.

*Sources: www.dhmi.gov.tr, www.akdeniz.edu.tr/, www.etsmet.com/tr, www.turklim.org/, antalyaeah.saglik.gov.tr/, antalya.adalet.gov.tr/, www.mallofantalya.com.tr/ (15/11/2023).

The 5 meters resolution satellite image obtained before the application phase was transformed into a full square with equal pixels by adjusting its dimensions. The resolution of the image was set to 8 bits. Each location selected on the image was cut and extracted from the image with the help of the QGIS program by entering coordinate information and saved individually as separate images. In total, 15 images were obtained together with the original image. The image with each extracted location has the same 8-bit size as the original image. The area of the extracted locations in the images has been converted into Nodata, that is, without pixel values. Thus, in the process to be performed for pixel-based projection in the Definies program, the values of the extracted places are "empty". and the change in the entropy value will be observed on a holistic basis. With this preliminary study, the preparatory phase for GLCM entropy analysis is completed (Figure 5).

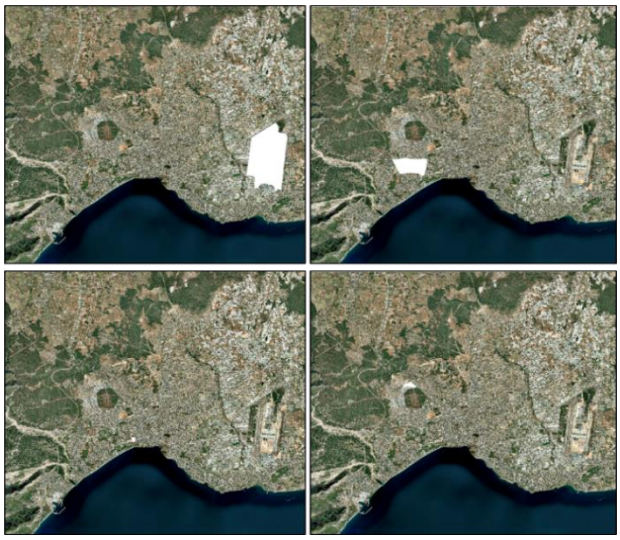

Fig. 5. Spatial examples extracted from Antalya satellite image for GLCM entropy analysis

In the application, firstly, the original 8-bit image edited in the QGIS program and without removing any spatial elements from the city was opened in Definiens software. Since GLCM has a square-based working system, the pixel dimensions of the existing image were equalized and squared. The pixel dimensions of the scaled image were converted to 60416*60416. Then, the Chessboard Segmentation algorithm was applied to evaluate each pixel in the image equally. Before the analysis of texture parameters, the existing image must be normalized. For this reason, the images were first normalized according to the formula (Table 2). Then, calculations were made with the GLCM entropy formula (Table 3).

The first image analyzed is the original Antalya satellite image, from which no locations were extracted. After calculating the 0°, 45°, 90°, 135° entropy values of the original satellite image, the values calculated from these four angles were summed and averaged to obtain the ALL value. Thus, a total of 5 values were obtained for the image with 4 different angles and 1 average value. These procedures were then applied to the image of each location. In the first step of the analysis, it is essential to calculate the values of the original image because there should be a constant image value to reference the spatial parts extracted from the image. The results of the GLCM entropy analysis of the locations will be evaluated based on the original image. The same steps as for the original image were applied for each image and the entropy values for 0°, 45°, 90°, 135° and ALL were calculated for each image. The results for each image are consistent. The results are detailed in the findings section.

Table 2. Normalization formula before analysis

Method	**Normalization Formula**
Entropy	$P_{i,j} = \frac{V_{i,j}}{\sum_{i,j=0}^{N-1} V_{i,j}}$
i: Number of rows (reference pixel value), **j:** Number of columns (number of neighboring pixels) $\boldsymbol{V_{i,j}}$: i and j cell values in the matrix	$P_{i,j}$: Normalized values of cells i and j N: Number of rows or columns

Table 3. Entropy process formula

Parameter	**Formula**
GLCM Entropy	$\sum_{i,j=0}^{N-1} P_{i,j}(-\ln P_{i,j})$
i: Number of rows (reference pixel value) j: Number of columns (number of neighboring pixels) $\mathbf{P_{i,j}}$ Normalized values of cells i and j	Since the ln(0) operation is not defined, this value is; It is accepted as ln(0) = 0. Value range: [0;90]

Results

With the spatial analysis performed, GLCM Entropy values of the original satellite image of Antalya city and the images from which 14 function spaces were extracted were obtained. The values include four different directions, 0°, 45°, 90° and 135°, and the ALL value obtained from their average (Figure 6). In total, 75 analysis values were obtained with 5 different calculations of 15 images. In order not to cause confusion in the evaluation of the analysis and to reach the most accurate result, only the ALL, i.e. the average value, was taken as the basis. In all images, the values of different directions are already in parallel with the ALL value. The original image of Antalya city is defined as "General" in the table. The data of the places are shown with the name of the function each of them has. In order to make it easier to understand the results of the analysis, the difference between the ALL value of the original image and the ALL value of the images of the places is indicated in a separate column in the table. It is understood that the higher the value differences, the higher the entropy of that space. According to the results of the analysis, the ALL-entropy value of the "General" image, which covers the whole city, was calculated as 8.438199. There is a high entropy in the whole city. This value expresses the entropy carried by the city with all its elements. This value was taken as a basis in the evaluation of spatial entropy.

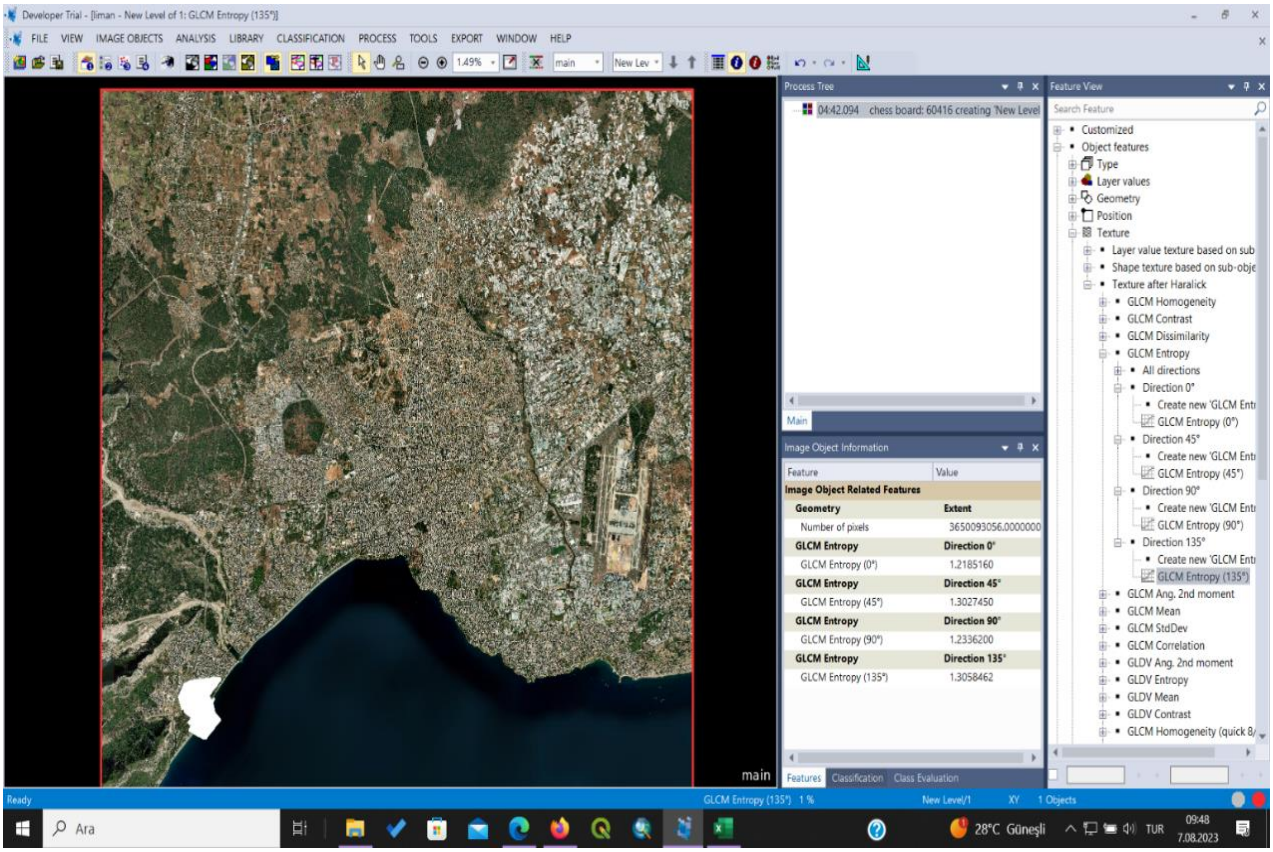

Fig. 6. Example of entropy calculation for selected places

Table 4. Entropy values calculated according to functions

Functions	0°	45°	90°	135°	ALL	Difference
General	8,2273832	8,5719291	8,3045415	8,5839757	8,4348199	-
Military	3,9204209	4,144477	3,9560626	4,1539625	4,0549082	4,3799117
Religious	5,0606245	5,3362762	5,1075348	5,3479223	5,2270243	3,2077956
Education	1,2605625	1,3471933	1,2777051	1,3553955	1,3120888	7,1227311
Economic	3,2107273	3,4017585	3,2419274	3,4120934	3,3251835	5,1096364
Law	3,7196002	3,9353537	3,754278	3,9451258	3,8491218	4,5856981
Administrative	4,5571879	4,8117597	4,5991271	4,8220024	4,7104601	3,7243598
Cultural	2,1933658	2,3309447	2,2185295	2,3402776	2,2750945	6,1597254
Health	2,9899479	3,1702135	3,0199517	3,1812747	3,0979938	5,3368261
Art	4,8719538	5,140052	4,9170456	5,1511829	5,0336769	3,401143
Industry	2,3720357	2,5208741	2,3985813	2,5310858	2,4608231	5,9739968
Sport	2,6332612	2,7976691	2,6616045	2,8078958	2,7313929	5,703427
Commercial	**1,218516**	**1,302745**	**1,23362**	**1,3058462**	**1,2667397**	**7,1680802**
Tourism	1,8810442	2,0012306	1,9030702	2,0099186	1,9521189	6,482701
Transportation	**0,618759**	**0,6625285**	**0,6275882**	**0,6630246**	**0,6436364**	**7,7911835**

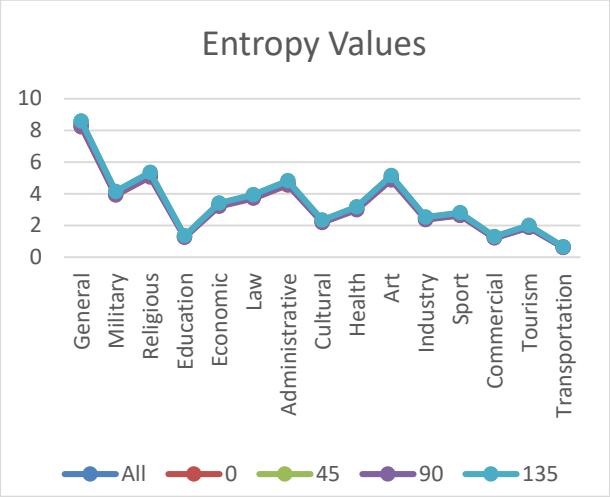

Fig. 7. Entropy Values Graphic

There are significant value differences in the results obtained for 14 places. It is thought that function, area size and spatial differences are effective in the occurrence of these differences (Table 4) (Figure 7)

According to the results, the highest entropy difference was realized at Antalya Airport, which is a transport function space. The ALL-entropy value of the airport was calculated as 0.6436364. There is a difference of 7.7911835 between this value and the original image and a very serious decrease has occurred. Therefore, when it is removed, it is determined that the airport is the spatial area where the integrity of the image is the most disrupted and the irregularity increases the most. The obtained value difference shows the accuracy of the relationship between entropy and function space. As it is known, Antalya, which has achieved rapid growth with increasing tourism activities since the 1980s, has become the most important tourism city of our country. Undoubtedly, the airport has a very important effect on the development of Antalya tourism. Surrounded by mountains from the north and west, Antalya has had difficulties in land transport throughout history. Its connection with the inland regions is still provided by passes between the mountains. For this reason, the development of different types of transport has been inevitable. Antalya Airport is the primary option especially for international connections. The majority of incoming foreign tourists use the airline. In our country, it is the airport with the highest number of international passengers with 25 million after Istanbul Airport. According to the results of our analysis with these features, it is not surprising that Antalya Airport ranks first in terms of entropy value. Certainly, having the largest area is another important factor in the emergence of this value (Table 4) (Figure 7). After Antalya Airport, the second largest entropy difference is Antalya Sea Port, which is a trade function place. The entropy ALL value of the seaport is 1.2667397 and the difference with the original image is calculated as 7.1680802. Apart from tourism, Antalya is an important agricultural and industrial city and its exports are mostly carried out through the port. The remarkable point is that the port, like the airport, also assumes a function that offers an alternative transport option to the highway. Thus, it is not surprising that the entropy values of the places that provide the connection of a place like Antalya, which is on the way to becoming a world city, with the outside world are high. Antalya Seaport is large in terms of areal size, but it is not in second place. In this direction, it has been determined that areal size is not the only factor. Another remarkable point about Antalya Airport and Antalya Seaport is that the two places are located at the east and west ends of the city. It has been observed that the entropy value of the places that are relatively far from the complexity of the city is higher (Table 4) (Figure 7).

The following places in terms of entropy values are Akdeniz University which fulfils the educational function, Konyaaltı Coast which fulfils the tourism function and Kaleiçi which fulfils the cultural function. Akdeniz University, one of the leading universities of our country, makes a great contribution to the city with its faculty and number of students. Konyaaltı Coast is the most prominent beach area in the city and constitutes one of the hot tourism spots. ALL entropy values of these two functions are below 2. Kaleiçi is the core of the city and the old city center. Today, such places represent the city's unique identity and history, and most of the consumption and entertainment centers are located in these areas (Geniş, 2011). Although Kaleiçi had a residential purpose for Antalya until the mid-republican period, it has now assumed a different function within the growing city and its entropy value has become different.

The other important function spaces are industrial, sports, health, economic, legal, military and administrative. These places are located in relatively smaller areas and closer to the city center. Eti Electrometallurgy Ferrochrome Plant, which fulfils only the industrial function, has a large area and is located in the north of the city. It is noteworthy that the administrative function is behind the other functions. The areas with the lowest entropy values were identified as art and religious places. Their entropy value is above 5. This shows the low impact within the city. With this inference, it can be considered to give more intensity to artistic functions. Since the number of religious places is high in the city, the low value of a single place may not be considered important. In addition, Muratpaşa Mosque is one of the smallest places in terms of area.

Discussion and Conclusion

Urban studies have recently diversified from social issues to a direction where digital data and remote sensing technologies are used. Providing different perspectives on urban phenomena and problems has become essential in a world where the urban population is increasing. It is seen that the methods and analyses used by various disciplines can also yield results in urban studies.

Although today's cities have similar landscapes and common spaces, it is not easy to analyze their urban meaning. Each place alone can be analyzed with different methods, but in order to understand its effect on the whole city, it is necessary to see its place in the overall picture. The main purpose of the study we have carried out is to understand the urban value of the places with different functions that every urbanite knows or needs. In this context, firstly by seeing the city in general and then calculating the value of the elements within it. In the research carried out with a part-whole understanding, the effect of entropy, one of the generally accepted laws of the universe on the subject, was wanted to be observed.

The data we obtained yielded interesting results about the city. The fact that the places with high entropy value have transport and trade functions and at the same time are related to air and sea is remarkable for the city of Antalya, where the road connection is weak. Especially the airport is of vital importance for Antalya tourism. The seaport plays an important role in the export of agricultural products. Any disruption of these two functions may cause very serious consequences for Antalya. In the city character of Antalya, where geographical conditions are extremely dominant, it can be considered to strengthen different transport options by using the possibilities of technology. In particular, the railway, which is today's leading mode of transport, will be an important option and will increase the tourism and trade potential of the city much more. The results we have reached show that places concentrated in education, tourism and cultural functions are other important areas for Antalya. These data do not contradict the reality of Antalya city. Places such as Akdeniz University, Konyaaltı Coast and Kaleiçi are of serious importance for Antalya. It is seen that other basic need spaces follow these functions. It is not surprising that for a city like Antalya, which has a high connection to the outside world, the places with national or international connections or the places that provide them are more important than local service places. In this study, constitutes an example for modern urban space analyses. The fact that the results we have reached are compatible with the urban reality has shown that it is an applicable method. Undoubtedly, different results can be obtained for different cities. In fact, even for the same city, different results may occur in different years. This will be a situation that depends on the conditions or entropy value of each city or time period. For example, in an image from the 1950s, the entropy value of Kaleiçi, which is a very small settlement area in Antalya, which probably means a great deal proportionally and spatially, will be very high. Such different results will pave the way for periodical analyses. In addition, our application can be useful in many different areas such as determining government or private investment points, market selection, determining urban hotspots, determining infrastructure facility installation areas. As a result, entropy is a method that should be considered in terms of urban spatial analyses.

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