ANALYSE OF BUILDING FACADES WITH FRACTAL METHOD: RAILWAY STATION BUILDINGS

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ABSTRACT
Software with the fractal dimension method has been created so as not to evaluate the facades subjectively in the work or the architectural facade analysis of Berlin-Bagdad railway station buildings in Turkey and to base the interpretations to digital data. Through the software, the track facades of the historical station buildings have been analysed. At the end of the analyses, though they are built different in different plan, size and fashion, it is discovered track there’s a definite proportion in the facade understanding of the station buildings. The software and the method used in the study will be able to be used in the following studies, in the typological classifying of different structure groups, determination of similar structure facades.

Key words: Historical Station Buildings; Facade Analysis; Fractal Geometry

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1. INTRODUCTION
The first railway road constructed in Anatolian lands was İzmir-Aydın track. The track the construction of which was started by an English company in the year 1856 was opened to operation in the year 1866. After the İzmir-Aydın track, the English company gets the franchise of İzmir-Kasaba track in 1863 and completes it in 1866. However, when the company turns over its all franchises to a French company in 1894, French company makes the track reach to Afyon (Uzuntepe, 2000). On the other hand, in 1871, Ottoman Government constructs the Haydarpaşa-Izmit track with state capital. Franchise of the railway track in the operation of which success is not achieved is passed on to German companies in 1889. Later, in the Berlin-Bagdad railway track project, many station buildings were constructed by German companies in Anatolian geography. In the terms of scale, plan, the stations built in approximately 20 different types bear a great resemblance in terms of facade understanding although they are different from each other. In this work, the mathematical proof of the similarities in the facade understanding of these historical stations is made by using
fractal geometry which has been used in many science branch yet started to be used in architecture area recently.

2. LITERATURE ABSTRACT

The definitions made in Euclidian space, which were disregarded in the beginning of the 20th century to the mathematic literature with the claims track it was incidental or chaotic, but today gaining an increasing importance with the explanations track it puts forward the scheme in the both physical and abstract phenomena, is named as fractal. Fractal geometry is used in the proofs for the physical problems, chemical equations, in biology and in many braches of science. The entrance of the fractal term in the architectural and designing disciplines doesn’t root to long past, but reflects on the researches ad a new analyse method. In the recent years, the “method quests” in the architecture discipline, has headed for the works to systems like fractal track gives clear data because of the fragility of the subjective interpretations and their complexities. Fractal method is thought to be a helper in the analysis of facade systems and the solving of mathematical proportion complexities as well. The fractal dimension analyse used in the analysis made with the fractal geometry was started to use in the buildings and buildings’ surrounding analysis in beginning of 1990s (Ostwald, 2001).

The applications of fractal geometry in terms of architectural can be called as the complexity of the components in the existing language of scale, Self-Similarity and architectural (Maletz, 1999). Mandelbrot (1982) states this about the usage of fractal in architectural in this way “A Mies van der Rohe building is a scale bound throwback to Euclid, while a high period Beaux Arts building is rich in fractals”. When the observation of fractal in this sense is done in architectural angle, we encounter with works from Hindu temples to Gothic cathedrals reaches forth to the architecture history. In this sense fractal term can be said to be systematic starting from component to whole, and related to natural and organic designing principles. Subjectivity comes as one of the fore leading problems in the facade questioning. This, both brings a biased viewpoint and causes open-end interpretations because they don’t have a digital base. In the sense, the geometrical concept track fractal suggests can eradicate the subjectivity. With the works done about the fractal, not just the facade analysis is aimed but also it’s aimed to eradicate other problematic matters track are very open-end to interpretation in terms of architectural.

Vyzantiadou vd analysed the grate and/or reticulated crust-ish structures with fractal system in their work done in 2006.

Galinski School designed in Berlin aimed to develop a method track can be a guide in architectural designs done in computer medium using the principles existing in fractal concept in format dictionary of a certain architectural language and in the production of architectural formats.

This approach is a design approach track supports the creativity in creation of new forms based on the fractal dimensions of an architectural texture and qualities (Beşe and Bahar, 2008). Salat (2011) did a research on the fractal texture of the cities and stated track modernist cities lost the fractal rituals and meanings. And also, a work area has been created under the name of city laboratory in this research and a formulation has been developed through fractal analysis. Chalup vd. (2010) did an inter-disciplines research about giving meanings between face recognition systems and architectural facades. Face expressions and facades were analysed with fractal. Tayloer vs. (2011) stated track perception researches track show visual interpretation
have a fractal pattern and aesthetical proportions in terms of fractals create a visual complexity. Salingaros (2012) did a research showing how fractal visuals affect during stressful working performances.

3. MATERIAL

Railway track facades of 0 station buildings built in 18 different types, in Anatolia by German companies in the beginning of the 1900s were used as the material. These are the track facades of the historical station buildings constructed in Marmara, Middle Anatolia and Akdeniz regions in different climates, in different size and fashions. The main reason of this as Burden (2000) stated is the concept of facade as the meaning of the outer front of the building is track it mostly cover the main front of the building which is the entrance and it’s characterized in details with stylistic details. Also, Krier (1988) says “if the front of a building is being talked about, sc. if the facade is being talked about, the front side track faces the street is being talked about.” Also many researchers have stated track the facades are the phenomena track emerges the characteristics of buildings, (Stamps, 1999) and submitted track facade is a language track can be explained with some mathematical terms like symmetry, asymmetry. For example Salingaros (2000) defends track asymmetry is a rough phenomenon, manifest of a shape by repetition, and should be used as linking only with an organized way an element in bigger scale.

On the other hand, architectural facades are physical places with stimulating quality. Facade components track form the identity and the language of a place form the characteristics of vicinity with their method of coming together and they affect it (Winters, 1986). As conclusion, the differentiations in the facade systems and partial design problems make the facade questioning necessary (Zelanski and Fisher, 1996).

The emergence of the buildings used in the work is in summary like this. Ottoman Empire sultan Abdülhamit II’s aim is not just a short railway but a long railway track that will make Istanbul reach to Basra. German politicians are in purpose of gaining raw materials from Anatolia and with the railway road track will go down up to Persian Gulf, by reaching to India in a short way, want to menace to England (Fraser, 1909). Despite the different purposes, as a result of the fact track the aim was mutual, Berlin-Bagdad railroad track project emerges. The company first buys the Haydarpasa-Izmit track for Anatolian railway part of Berlin-Bagdad railway road. Later on, they start making of the 486kms track. The track reaches to Adapazari in 1890, to Bilecik in 1891, to Ankara in 1893. Upon seeing the success achieved in short time, the franchises of the track that will reach to Kütahya, Afyon, and Konya from Eskişehir are given to the same German company (Albayrak, 1995). The construction of the track longitude of which is 444km and its start point is Eskişehir achieves a great success. Until 1894, tracks track are Eskişehir-Alayunt 77km, Kütahya-Afyon 95km, Afyon-Akşehir 100 km opened to the service. In the year 1896 the railway reaches to Konya (Efe, 1998). The stage of Berlin-Bagdad railway project obviously opposed by England, France and Russia, construction of Konya-Yenice start with the German Deutsche Bank buying the construction franchise of the track in 1899. In 1911, between Konya-Bulgurlu gets completed. In 1914, between Bulgurlu-Karapinar, Durak-Yenice, Adana-Mamure Toprakkale-İskenderun, Raco-Telebyat, Bagdad-Samra tracks which are 632km gets completed (Onur 1953). Although Germany fails to make this track reach to Persian Gulf and have a port there due to the English oppression, the projected which is carried out is an engineering success in terms of its size and conditions of the time.
According to the agreement made with German company, construction of a station in each 20km on the track is calculated and the characteristics of the stations are defined. According to the agreement, the area track stations cover won’t be less than 400m for main track and 300m for tali track. Buildings will be constructed with stone or brick materials and the top of them will be covered with tile or metal material (Efe, 1998).

So that, it’s seen from the historical document in Figure 2 track they classified the stations they built into four. However, then the existing stations are observed, it’s seen track plans in some stations are made bigger or smaller in the axle way of railway according to the need. On the other hand, the stations in Adana and in its close vicinity seem as one of the most attractive station types in Turkey with their architectural detail and original forms. These buildings constructed in two types among themselves are constructed in accordance with “orientalist approach”, the architectural understanding of track time. These buildings have sharp arches and have large inlaid wooden canopies.
In this case, it’s probable that, the cost calculations of the companies which got the franchise of the tract, the economic and political troubles that the Ottoman Empire was in and especially the number of the large settlements and the population in Anatolia decreasing to small numbers after the wars lasting for hundred years are effective. On the other hand, although it emerged in England, Germany which adopted new technology quickly and develop it and one of the fore leading countries in railway sector, built these station buildings with the similar plan schemes and facade grid layouts that they built in Germany.
4. METHOD
Fractal analysis which is sued in architectural designing leads a different approach especially in matters related to giving meaning to facades. In this sense, the importance of the facade analysis emerges. It will be a help in determining the differences in the size of architectural facade or in giving idea for a new facade speculation. It will support the emergence of the scale differences of both linear and speculative systems when studying the duration of the facades. As related to this, studies that Eglash carried out in 1999 in order to study the fractal texture of African architecture can be given as clear example.

Vaughan and Ostwald observed a visual complexity in the structure of an architecture with fractal dimension calculations in the study made in 2009. Fractal dimension calculations are based on 3 approaches.
Analyse of Building Facades with Fractal Method: Railway Station Buildings

- Self Similarity Dimension \((D_S)\)
- Measured Dimension \((d)\)
- Box Counting Dimension \((D_b)\)

Self-similarity dimension approach is used if a curve is produced from repeating parts which is similar to itself. Bovill (1996) measured this approach with a formula that develops the relation in the structures similar to each other, between the number of the small parts of the main body and scaling rate.

\[
a = \frac{1}{s^d} = \frac{1}{s^{D_S}}
\]  

(1)

If a number of part is \(s\), the Self-similarity dimension rate can be measured with the factor defined as reducing factor.

When using Measured Dimension approach, process of which measurement directory is measured and which approach is used is important. The natural formations on the earth are measured with measured dimension approach.

In the calculation of the fractal dimension of the complex two-dimensional speculative systems, previous approaches are not used. Because there’s no coastal line or alike curve that measured dimension approach can be used, and also there’s no clear repetition of a similar structure to itself (phenomenon) in two-dimensional complex speculation (Bovill, 1996).

With this side, we encounter with “box counting dimension” approach as the most mathematical approach that is most frequently used in measuring approximate fractal rate of an object. box-counting dimension, which has a simple intuitive formulation and is one of the most widely used dimensions. The definition goes back at least to the 1930s, and its popularity is largely due to its relative ease of mathematical calculation and empirical estimation.

Architectural details and repetitions can be studied with the approach mentioned. In the box counting dimension approach, the two dimensional facade drawing is divided into grids and the data in each square is checked (See Figure 6).

**Figure 6** Fractal Facade Analyse Grid Example (Source: Haştemoğlu&Erkan, 2013).
Facades that are divided into grids, the lines related to the facade in each square are determined. Grid boxes that have data inside are counted. Available grid layout sizes are reduced with levels and it’s continued so. (See Figure 7)

\[
D = \frac{\log(x) - \log(y)}{\log(z) - \log(q)}
\]

Here, D, fractal rate; x, the number of the counted full box in the next spin; y the number of the full boxes in the previous spin; z, the number of the boxes in sub line in the next spin; q, the number of the boxes in the sub line in the previous spin.

The fractal dimension that results from box counting approach changes from 1 to 2. The more it’s close to 1 shows the plainness of the facade speculation, the more it’s close to 2 is the gauge of the complexity. Bovill (1996), the box sizes are determined according to the details that are in the ken resulting from the distance between the observer and the building, boxes show the observer’s ken. Naturally, it shows that buildings get smaller as it gets closer to the buildings. Developing an algorithm in the frame of the defined analyse, this algorithm analysing with the Box counting dimension can analyse facade speculation as fractal. The algorithm of the method is defined in the Figure 8.
The software mentioned that is based on algorithm is developed with visual studio. The software is able to divide the drawing into grids by using Box Counting Dimension according to the submitted column and line rates, and is able to calculate the number of the pixels in each full box.

It’s able to calculate the number of full/empty squares by checking each pixel whether it has line or not in each box. After carrying out the grid system in small scale, the data is reached to fractal rate with the formula that Bovill (1996) developed. This fractal rate can be reflected into graphic. Along with this, as the Bovill (1996) stated, the drawing that will be uploaded to the programme will be drawn with auto cad software with definite line thickness, and the lines that emerge due to the difference in material, stone/glass artistry roof texture and various decorations won’t be included in the drawing. The programme also supports jped format. The interface of the developed software is seen in the Figure 9.
Figure 9 Interface of the software

The software can detect the number of the loops in the facade analysis. Algorithm, about the uploaded picture, first by dividing it into 8x8 squares searches line/data in each square. It continues the same operation 10x10, 15x15, 20x20 and 25x25 squares. Later on, it calculates the fractal rate of the 1-2, 2-, 3-4 and 4-5 loops. This calculation also gives the average fractal rate of the facade. The system also offers making multi-facade comparisons on graphic by turning these calculations into graphic analysis. In the Figure 9, the fractal rate of the entrance facade of the station building analysis of which is made is calculated as 1.53.

5. RESULT AND DISCUSSION
With the software developed, fractal dimension, in terms of architectural analysis will bring a new approach. The importance of the study is that, it’s done for station buildings that are in different plan, size and fashion. This situation will result as a chance to analyse different groups of structures with the application. The analysis results of the mentioned structures are shown in the Table 1.
### Table 1: Fractal Results of the Entrance Facades of the Station Buildings

<table>
<thead>
<tr>
<th>Name of the station/Photo</th>
<th>Track Facade</th>
<th>Fractal Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 İzmit</td>
<td><img src="image1.png" alt="Image" /></td>
<td>1.71</td>
</tr>
<tr>
<td>2 Büyükderbent, Sapanca, Mekece Osmaneli, Karaköy, İnönü Beylikköyprü, Beylikova</td>
<td><img src="image2.png" alt="Image" /></td>
<td>1.61</td>
</tr>
<tr>
<td>3 Vezirhan, Alifuatpaşa</td>
<td><img src="image3.png" alt="Image" /></td>
<td>1.62</td>
</tr>
<tr>
<td>4 Doğançay</td>
<td><img src="image4.png" alt="Image" /></td>
<td>1.65</td>
</tr>
<tr>
<td>5 Bozüyük</td>
<td><img src="image5.png" alt="Image" /></td>
<td>1.56</td>
</tr>
<tr>
<td>6 Bilecik, Alayunt Kütahya, Aksaray</td>
<td><img src="image6.png" alt="Image" /></td>
<td>1.6</td>
</tr>
<tr>
<td>7 Eskişehir, Ankara</td>
<td><img src="image7.png" alt="Image" /></td>
<td>1.8</td>
</tr>
<tr>
<td>8 Yunusemre, Sazak, Biçer, Alpu Sazilar, Maliköy, Etimesgut, Sincan</td>
<td><img src="image8.png" alt="Image" /></td>
<td>1.61</td>
</tr>
<tr>
<td>9 Gökçekeşık, S.şimar, İlhisaniye,Sultandağı, Gölçayır, Gözpinari, İlgın, Kadınhanı, Sarayönü, Meydan,Pınarbaşı</td>
<td><img src="image9.png" alt="Image" /></td>
<td>1.62</td>
</tr>
<tr>
<td>10 Afyon</td>
<td><img src="image10.png" alt="Image" /></td>
<td>1.67</td>
</tr>
<tr>
<td>11 Konya</td>
<td><img src="image11.png" alt="Image" /></td>
<td>1.81</td>
</tr>
<tr>
<td>12 Karaman, Ereğli</td>
<td><img src="image12.png" alt="Image" /></td>
<td>1.74</td>
</tr>
<tr>
<td>13 Kaşınhan, Çumra, Arıkören, Demiryurt, Sudurağı, Ayrancıderbent, Bögecik</td>
<td><img src="image13.png" alt="Image" /></td>
<td>1.76</td>
</tr>
<tr>
<td>14 Çakmak, Ulükışla, Çiftehan, Pozantı</td>
<td><img src="image14.png" alt="Image" /></td>
<td>1.65</td>
</tr>
<tr>
<td>15 Hacıkırı, İslahiye, Çobanbey</td>
<td><img src="image15.png" alt="Image" /></td>
<td>1.66</td>
</tr>
<tr>
<td>16 Adana</td>
<td><img src="image16.png" alt="Image" /></td>
<td>1.63</td>
</tr>
</tbody>
</table>

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When the station buildings average fractal rate of which are given are all analysed and compared Figure 10 will appear.

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Fractal Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Durak, Yenice, Zeytinli, İncirlik, Yakapınar, Ceyhan, Günyazı, Osmaniye</td>
<td>1.58</td>
</tr>
<tr>
<td>18</td>
<td>Toprakkale, Erzin, Dörtyol, İşkenderun, Karkamış</td>
<td>1.59</td>
</tr>
</tbody>
</table>

**Figure 10** The average fractal rate of the all entrance facade of the station buildings

This study showed that: when the station buildings in 18 different types and around 70 in number are observed, although these buildings are built in three different geographical area and different climates, though they have different plan type, size and architectural fashion, they bear a great resemblance in terms of facade regulation. The fractal rate is close to each other generally in buildings. Also, this study showed that, like in the station number 2 and station number 16, thought they don’t resemble each other in architectural sense at the first look, the thing that the facade regulation of them in fractal geometry point is very close to each other, is an important evidence of the similar facade regulation approach between stations.

**Figure 11** Facades of the station number 2 and the station number 16
6. FUTURISTIC STUDIES

We encounter with fractal studies as a new approach in analysis method, but, especially in Turkey, the architectural methods that are mentioned are carried out subjectively without being based on intuitive or any kind of analysis. Because these subjective approaches are not based on any digital data, they cause sometimes many different/not supported or sometimes unreal interpretations. With the help of the developed software, with a system, new analysis that are far from subjective interpretations, can be based on digital data, that interprets with “digits” will be carried out.

These analysis by being used in construction groups’ classifications, in determining typology studies, in historical texture studies, will enable us to reach data that’s based on the mathematical basis without just the experience of the expert who carries out the study.

REFERENCES