Measurability of Loos' rejection of the ornament

Using box-counting as a method for analysing facades

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As evidence from recent years has demonstrated, box-counting provides an objective fractal analytical method to evaluate the visual complexity of architecture. This paper for the first time explores the potential of box-counting with regard to the work of the Viennese architect Adolf Loos (1870-1933). Loos is seen as the pioneer of modern architecture, as someone who anticipated the International Style. This impression derives from his resentments towards the ornament, expressed especially in his texts. However, Loos did not reject ornamentation in general. Thus, the group of smooth plastered facades provides a narrowed view on his overall architectural concept. A more differentiated view on Loos' oeuvre is not new; however, the author further develops the possibilities of describing facades geometrically by using an implementation of the fractal analytical method, especially created for facades. This paper not only focuses on the possibility of grouping facades with similar characteristic values, but considers other aspects of Loos' design such as space as well.

Keywords: *Box-counting, Adolf Loos, Complexity, Fractal geometry*

MOTIVATION

Benoît Mandelbrot (1981, 1982), the "father" of fractals, argues that modern architecture expresses an affinity to scale-bound objects, and hence looks smooth. However, the author reveals that Loos' view does not necessarily yield smooth facades. From the very beginning Loos appears as a pioneer of modern architecture of plain, unornamented buildings, due to both his theoretical work and the first publication of Steiner House in 1910. The smooth facade of Steiner House is, however, only one facet of Loos' style. On closer inspection, two aspects are particularly noticeable about Loos' oeuvre: First, the outer appearance of his buildings is not necessarily smooth, but, on the contrary, diversified. Throughout his whole work, smooth cubic designs alternate with classic-style villas, timber constructions and conversions. Second, Loos accomplishes a manifold sophisticated whole by focusing on two strategies, the difference and interaction between an inner and outer order and the refined use of symmetry. Those aspects support the author's assumption

that the complexity of Loos' facades is both, independently of the year of construction and of varying degree. This paper has, therefore, two objectives: in order to verify the diversity of Loos' facades, their complexity is first analysed with the help of an objective comparison method, and then, based upon this analysis, the division into groups of similar characteristics is discussed. At the same time, the results are also evaluated in relation to Loos' essential idea of space.

INTRODUCTION

Beside Peter Behrens and Frank Lloyd Wright, Loos ranks among the most important representatives of the first modern movement (Hitchcock 1994). His thoughts about architecture do not only find their theoretical expression - published in numerous articles - but manifest themselves in his buildings. However, Loos' concepts cannot be judged by his probably most frequently cited and famous pamphlet "*ornament and crime*" (Loos 1997 [1908]) only. In his theoretical articles, he primarily criticizes the architectural practice of his time - the arbitrary use of ornamentation without any reference to an underlying concept. It was the time of Historicism when architectural and decorative elements of the past were used devoid of their former significance. However, he also attacked new movements in architecture which developed their own independent ornamentation. The "Secession" movement, for instance, a Viennese variety of Art Nouveau, did not meet his expectations either (Tournikiotis 1994).

Influences

It was during his stay in the United States between 1893 and 1896 that Loos decisively shaped his thoughts about culture and architecture. In the purism of an American suitcase he found the definition of modern style: "*functional is beautiful!*" (Scheu 1909). Loos may also have been influenced by the ongoing discussion of Louis H. Sullivan on the restrained use of ornament (Ungers 2002). Frequently used elements, such as the two-storey central living hall, the fitted wardrobes and the fire place (niche) reveal a clearly American-British influence.

Additional sources of influence were his journeys to the Greek Islands and North Africa. The cubic and terraced buildings by Loos, for instance, bear resemblance to the flat cubes with sharply cut windows found at both destinations. Moreover, the concept of *Raumplan* (spatial plan) shows a striking similarity to the architecture of Greek islands (e.g. of Euboea). Both, the central high hall with adjusted gallery and the stairs of the outdoor area with intermediate places serve as inspiration (Kurrent et al. 1998). *Raumplan* is a term coined by his student H. Kulka (1931) describing the artistic three-dimensional arrangement of spaces.

"Ornament and Crime" and Steiner House

The publication of Loos' (1997 [1908]) well-known article "*ornament and crime*" started fierce discussion. According to Loos, contemporary artists were not able to produce adequate ornaments, and therefore it was better to dispense with ornamentation at all (Loos 1997 [1908], [1924]). Moreover Loos was convinced that the production of ornament wasted material and time. He, however, pointed out himself that he had never completely refused ornamentation (Loos 1997 [1924]).

In 1909 the owners of Goldman & Salatsch commissioned Loos with his first larger - and probably most controversial - work: the Looshaus on the Michaelerplatz in Vienna, completed in 1911. It was called 'the Viennese house without eyebrows', since the usual window roofings of that time were missing. The prominent location on Michaelerplatz opposite the back entrance of the Imperial Palace further enhanced public controversy. It was said that Emperor Franz Joseph not only severely objected to the Looshaus across the square, but also drew the curtains so that he would not have to look at it at all.

Another building created at the same time allowed Loos to realize his ideas of a building reduced to simple geometric shapes: Steiner House. In 1910, the year of completion, the smooth plaster facade of the front view was published in the journal "*Der*

Architekt". Without additional images from inside or floor plans, the sole publication of the front view not only established a connection with the Looshaus, but contributed to a preconceived opinion about Loos' architectural concept. Pevsner described Loos' radical rejection of ornamentation as the architect's decisive contribution, which he interprets as an anticipation and confirmation of the International Style (Kühn 1989, Khan 1998).

"Raumplan"

The concept of the interrelation of rooms in Loos' design is today known as *Raumplan*. Loos himself never used this denomination. His student Kulka (1931) introduced the term to describe differentiated spatial thinking. Three-dimensionality of architecture and interaction of rooms replace the two-dimensional way of thinking. The height and the position of a room depend on its purpose: The more private, the lower its height and the closer to the top of the building. The central "semi-private" hall occupies up to two storeys. The individual flights of stairs, rarely positioned one over the other, coil upward next to the rooms. This creates a composition of split levels with interesting experiences of space. Müller House shows a comprehensive realisation of *Raumplan*.

BACKGROUND

Basically, box-counting, the fractal analytical method used in this paper, identifies the minimum number of boxes of a certain size completely covering the object under consideration. The grid method - as a simplified extension - forms the basis for a script in VBA for AutoCAD, called "Box-counting steps", written by the author (Lorenz 2009, 2012). In particular, this implementation takes into consideration the peculiarities of architectural analysis: It uses a medium of the planning architect and due to the fact that it considers vector graphics instead of pixel graphics, neither the thickness of lines nor the resolution of the image influences the result. With this simplified method, a grid with a certain mesh size is placed over the object. For facades the object consists of all relevant lines, which is a matter of distance and visual perception. Relevant lines mark striking changes of direction or of significant material differences. In the next step, those boxes of the grid which cover the object (figure 1) are counted. As already demonstrated by Carl Bovill (1996) the largest and smallest mesh size again depends on the distance of the observer to the object and on the eye angle. In turn, the distance is a function of the height of the building and three different angles, 18°, 27° and 45° (Maertens 1884). Based on these studies the author defines the upper and lower bounds for box sizes (Lorenz 2013). Finally, while reducing the box-size the amount of covered boxes changes as well. The box-counting dimension is defined by:

$$D_B = \lim_{\epsilon \to 0} \frac{\log\left(N_\epsilon\right)}{\log\left(\frac{1}{\epsilon}\right)} \qquad (1)$$

If a relationship between size and scale exists - at least for a certain range of scale before the elevation dissolves in its one-dimensional lines -, this can be clarified in a log-log graph. Data points then nearly follow a straight line or more precisely they are close to a regression line. Finally, the slope of the regression line (equal to DB) gives the ratio of irregularity.

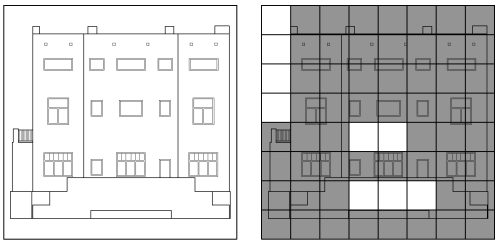


Figure 1
Box-Counting method demonstrated with Steiner House (gray coloured boxes are counted)

According to Lewis Frey Richardson (1961), the length of coastlines is hard to determine. This is due to the fact that the length depends on the scale of the map used. Thus, he was able to establish a relationship between total length and scale. This relation was given by a power law. Benoît Mandelbrot, the "father" of fractals, related the exponent to what he called fractal dimension. Fractal dimension

is a characteristic value for fractals. In order to estimate the fractal dimension different methods exist, for instance box-counting, which Bechhoefer and Bovill (1994) applied to architecture for the first time.

Analyses and Evaluation

According to C. Bovill (1996), box-counting calculates the approximate visual complexity of facades. However, the result of any measurement depends on various influences (Foroutan-pour et al. 1999, Lorenz 2003, 2009). In order to minimize influences, and as a result of previous works (Bovill 1996, Foroutan-pour et al. 1999, Ostwald et al. 2008), the author's implementation "box-counting steps" allows adjustments of influential parameters via an input form. As a consequence, the analysis of each facade considers a set of measurements with different adjustments. The set is then critically assessed by statistical methods (visualized in a box-plot). In order to obtain the most significant possible result, it is important that

- every single measurement offers only little or no deviation: a coefficient of determination $R^2 = 0$ indicates no relation, while $R^2 = 1$ means highest possible correlation,
- the set of measurements has a small interquartile range, which is the range of the box-plot containing 50% of all values: the smaller this range, the smaller the fluctuation of data-points.

For the data analysis by the author several values are important (the median, the interquartile range, the smallest and the average coefficient of determination and the range of scale), since they provide information about coherence across scales.

Results

The author focuses on whether the complexity of Loos' designs changes over the years or remains on a similar level. It is, therefore, the measurement of visual complexity that provides new insight into Loos' work, both in terms of his buildings and his theoretical work. The paper analyses nine residential houses from all periods of Loos' creative work, including four unrealised projects and two conversions (table 1 and figure 2). The author's new drawings as vector graphics ensure equal treatment of the data. The study work of the Technical University of Munich (Kurrent et al. 1998) served as an important source. While seven buildings consist of four elevations each, two, as annexes to a neighbouring plot, have three elevations each. In sum, the analysis of this paper comprises 34 elevations. Each individual measurement set (for a single elevation) consists of ten different measurement settings. As they, in turn, consider different starting points, the total number amounts to 60 single measurements for each facade. In order to guarantee some consistence of all measurements, several influences on the results have been minimized as follows:

- every elevation has been prepared in the same manner (i.e. the author considered the same sort of architectural elements, and used the same scale of preparation),
- every set consists of the same number of individual measurements with exactly the same measurement settings,
- the average coefficient of determination for each facade amounts to at least 0.998 and
- thus, in order to compare different building sizes, the smallest and largest mesh size is set in relation to the height of the facade (displayed as a percentage value).

Name of the building	Place	Year
Hugo and Lilly Steiner House	Vienna	1910
Dr. Gustav and Helene Scheu House	Vienna	1912-1913
Mandl House *(conversion)*	Vienna	1916
Villa Konstandt (project)	Olmütz	1919
Villa Strasser (conversion)	Vienna	1918-1919
Villa Stross (project)	Vienna	1922
Paul Khuner country house	Kreuzberg/ Payerbach	1929-1930
Dr. Hugo and Lisa Bojko House (project)	Vienna	1929-1930
House for Dr. Müller's daughter (project)		1933

Table 1
List of analyzed buildings

Figure 2
Analyzed buildings (left to right - listed in table 1 starting from the top)

A sharp bend in the data curve

When analysing the data, we note that the west view of Steiner House displays a sharp bend in the data curve of every single measurement (left image of figure 3). The author has already been able to observe a similar behaviour in case of two other representatives of modern architecture: Villa Savoye by Le Corbusier (Lorenz 2012) and Villa Tugendhat by Mies van der Rohe (Lorenz 2013). The sharp bend clearly separates two ranges of scale with different slopes: while the first section displays a steeper slope, the second one becomes flatter. As the former comprises larger mesh-sizes, it can be deduced that the elevation is of greater complexity when viewed from a greater distance. At a certain scale the behaviour suddenly changes and the elevation tends to be smoother. Thus, the gradient angle of the regression line and, subsequently, the box-counting dimension (as its equivalent) flatten alike. The turning point is equivalent to the change from the dominance of the windows towards the smooth plaster surface. However, when all measurements are considered, it turns out that the data material of the second section is more consistent than the data of the first section. It is the interquartile-range of the box-plot that displays the difference (right image of figure 3). The following buildings belong to the category with a sharp bend in the data curves:

- Scheu House (all views)
- Steiner House (all views; west and east view with a clearer sharp bend)
- Mandl House (all views; west and east view with a clearer sharp bend)

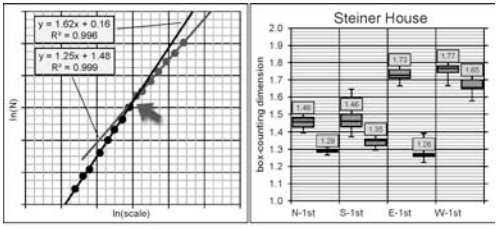


Figure 3
Analysis of the west view of Steiner House: one single measurement (left) and box-plot diagram of the set of measurements (right)

The smooth facades of Steiner House with regularly arranged and sharply cut windows seem to have influenced Le Corbusier. However, Le Corbusier in contrast aligns the window flush with the outer

surface, which has the effect that the volume of the building becomes even more apparent (Hitchcock 1994). In his dissertation, the author has already pointed out the similarity of the results between the garden (east) facade of Steiner House and the south-east facade of Villa Savoye by Le Corbusier (Lorenz 2013). Both display a clearly sharp bend in their data curves (Lorenz 2012). For the first section of larger distances, the median value of the garden facade of Steiner House amounts to 1.73. The first section of the south-east facade of Villa Savoye, in turn, achieves 1.60, a slightly lower value. However, for the second range the differences between both buildings are marginal: 1.26 for the garden facade of Steiner House and 1.28 for Villa Savoye. These results support the conclusion that both facades are of a higher visual complexity viewed from a larger distance than from a smaller one.

The street (west) and the garden (east) facade of Steiner House, the three facades of Scheu House and the street (west) and the garden (east) facades of Mandl House display a similar median. All values remain between 1.65 and 1.78. However, what is striking about Steiner House is that for the two side walls the point of change appears earlier - at a mesh-size of about 2.3 meters. Moreover, their medians for the first section are smaller - in both cases 1.46 (for further details see section "*Opposite sides with similar results*"). All views of Mandl House, representing the other extreme, display higher values in the second section, with higher complexity of this scale range. This is mainly due to the fact that it is a conversion and expansion. Visually, the result is underlined by a higher level of detail on smaller scales: cornices, wooden elements and the pattern of smaller elements of the railing.

Similar results for all elevations of one and the same building

Some of the analysed buildings show similar results for all views over a large range of scale (table 2). This suggests a similar complexity not only for all sides but also independently of the considered scale. Scheu House clearly belongs to this group of buildings, as the medians of all three elevations remain between 1.65 and 1.68. The reasons for those results are twofold: First, size-differences between elements are similar and, second, their number increases when size decreases. Primarily, the three levels of size include the whole elevation, the windows and the smaller elements of the skylights. By contrast, symmetry is no decisive criterion, as only the east view of Scheu House is symmetrical.

Name of the building and view	D_B
Scheu House (all views; first section*)*	1.65-1.68 (diff. 0.03)
Mandl House *(east, south and west view;* second section)	1.41-1.42 (diff. 0.01)
Khuner country house (all views)	1.79-1.83 (diff. 0.04)
House project for Dr. Müller's daughter (north, east and west view)	1.82-1.86 (diff. 0.04)

Table 2
Buildings with similar results in most of their views

The outlier of Mandl House concerns only the second section of the north facade. The lower median is due to the large facing surface of the mansard roof and to the large windowless area of the facade. On the opposite side the smoother effect is reduced by the tent-roof covered tower-like annex and the flat-roofed side annex by Loos, but also by the pillars for the open canopy. Thus, the south side receives similar characteristics as both gable-views of the half hipped roof with different architectural elements.

Khuner House, a wooden construction with balconies on a natural quarry stone foundation, offers a completely similar characteristic for all views. A similar behaviour occurs at the project for Dr. Müller's daughter. In this case, only the south view represents a slightly smaller value (1.76). This is due to the outer smoothly plastered chimney, which occupies part of the facade.

Opposite sides with similar results

For the first section the opposite sides of Steiner House display similar results (table 3). Parallels and similarities can be identified between either the street and the garden view or both side views. For all views the design of the windows is - apart from their formats - similar, depending on the scale of consider-

ation. The same is true for the order of magnitude of elements from the large to the small scale. Nevertheless, the measurements of the less visible side-views result in smaller medians. While the street and the garden view display symmetry (only slightly broken), this characteristic changes to a free distribution at the other two facades. However, the differences between the two pairs of facades occur due to the ratio between empty (smooth) areas and those with significant lines. Larger smoothly plastered areas at the side-views correspond to smaller medians. However, both the street and the garden view display high values above 1.7 until the sharp bend in the data curve occurs.

Table 3
Buildings with similar results for opposite views

Name of the building	street view	garden view	side 1	side 2
*Steiner House (*first section*)*	1.77	1.73	1.46 (north)	1.46 (south)
Strasser House	1.76	1.76	1.62 (east)	1.58 (west)
Villa Stross	1.64	1.62	1.51	1.54

Strasser House, although a conversion, presents a similar division. Both side views, again, appear smoother due to larger empty areas of the facade. In turn, higher medians for the street view and the rear side reflect higher complexity, this time for a larger scale range. On smaller scale, for instance, plate connections of a quarter-round tin roof determine in both cases the entire top parts. Furthermore, the otherwise continuous classical cornices are interrupted at the side views and the ratio of the vertically structured balcony balustrades is smaller.

The unrealized Villa Stross, a representative of Loos' classic villa-style architecture, belongs to this group as well. The street and the garden view are dominated by strict symmetry and axiality. Differences occur due to the deep, high loggia and colossal Ionic columns of the garden view and the extensions and terraces of the street view (Risselada 1988). In contrast, the sides views are less structured and again consist of large empty areas.

DISCUSSION

As could be demonstrated in the previous section, the study of Loos' work with regard to its complexity reveals no correlation between the year of design and the degree of complexity. This confirms the assumption that Loos' design concept cannot be reduced to the rejection of ornamentation, but comprises different outer appearances. Moreover, most results - apart from those with separate data-curves - reveal astonishingly high levels of complexity for a large range of scales. In order to perform a more detailed analysis the following section utilises a description of Loos' buildings according to design features.

Smooth cubic and terraced buildings

Buildings of plane facades with sharply cut windows, summarized in the group of cubic and terraced buildings, repeatedly occur throughout Loos' work. According to Loos, the object of utility (and most pieces of architecture) should be considered separately from the art, and thus requires no decoration (Loos 1997 [1909], [1924]). The aesthetics of a utility object is exclusively derived from a material-specific, functional and resources-conserving realization.

If one considers the interrelation between inside and outside, two subgroups emerge: (1) facades, which are designed from inside to outside, where the outer appearance is, however, subject to a separate order, and (2) facades, whose openings, at first, appear disorganized and arbitrary, but correspond to the internal order (Kurrent et al. 1998). While Steiner House belongs to the first subgroup, Scheu House - according to Kulka (1970) the first terrace house in Central Europe - belongs to the second. Although all facades of Steiner House avoid ornamental decorations, it is especially the garden facade with the upper end of a flat roof where nothing distracts from the clear form. Nevertheless, some characteristics of this side of the building refer to the vocabulary of classicism: the middle and side risalits and the strictly symmetrical arrangement. These belong to the outer order. In contrast, the eastern view of Scheu House clearly demonstrates the correspondence between

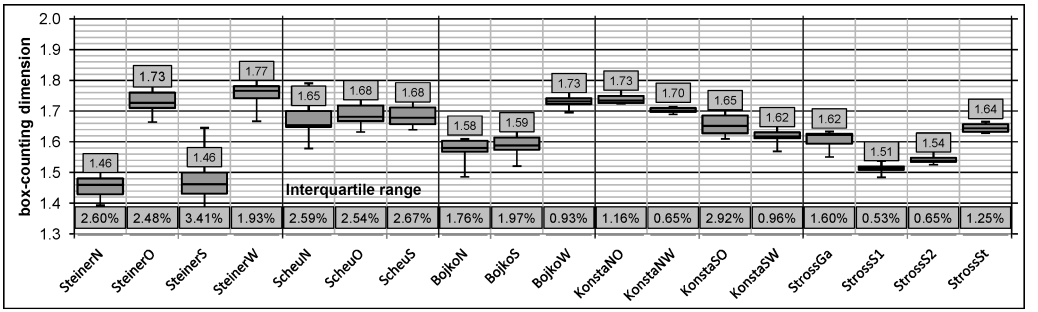


Figure 4
Smooth cubic and terraced buildings; Buildings with reference to classical antiquity

the size of openings and the purpose of the room behind. Scheu House, although part of the smooth cubic examples, displays again high values at least for a certain scale range.

An apparently smooth facade does not necessarily lead to a sharp bend in the data curve. For example, Schröder-Schräder House by Gerrit Rietveld shows a consistently constant slope down to very small mesh sizes (Lorenz 2013). Bojko House, a three-storey terraced cubic building by Loos has similar characteristics, but remained a project. In contrast to Steiner House and Scheu House, none of the three views displays a sharp bend in the data curve. This suggests that Bojko House, a later representative of smooth cubic buildings, is more balanced with regard to scale. It displays high results for a large range of scales. Only the western facade has a slightly higher value because of both the material of the enclosure and of an annex and the balcony with horizontal lines of the parapet ranging across the entire width (figure 4). However, the scale ranges are the same for all three facades.

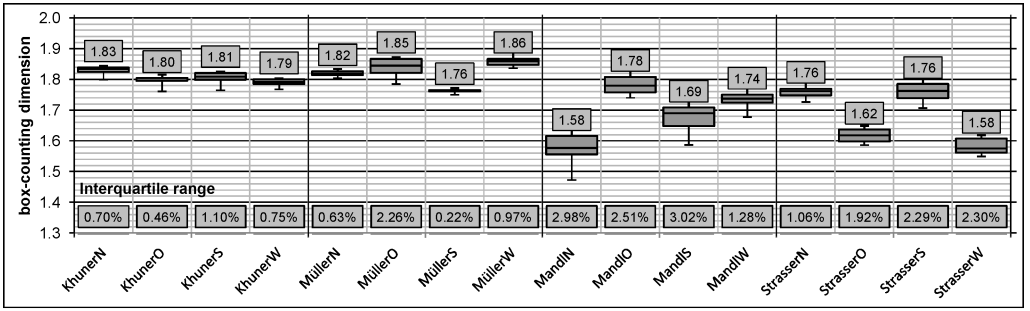
Classic villa-style architecture

Loos' rejection of ornamentation from earlier architectural epochs does not necessarily result in a complete rejection of references to past styles. Although the use of classical or neo-classical vocabulary of forms appears mainly at unrealised buildings (Tournikiotis 1994), it is not completely unfamiliar to Loos' work (compare Steiner House). However, the main topic is the continuous development of the inner order, which Kulka (1931) later called the *Raumplan*. While Villa Konstandt already shows room levels, it is Villa Stross that indicates the principles of *Raumplan* (Kurrent et al. 1998). The classical facade with its own order does not oppose the inner order. The use of symmetry demonstrates the conflict. While the facades offer one level of reflection symmetry, the inside is rather a (time) sequence of symmetries. Time sequence means that every room has its own symmetry whose axis is not continued to the next room. When one crosses one room after the other, one passes from the one symmetry to the next. Symmetry in a room includes cases where a prop or a chimney is juxtaposed (mirrored) by a wall closet. When the outside mirrors the inside, they finally offer complex interlocking between symmetries and spatial axes.

The results for all facades of Villa Konstandt and Villa Stross show certain variation (figure 4). In the case of Villa Konstandt, differences are due to the sloping terrain. The base area of all four views consists of exposed masonry, which, in general, leads to a higher fracture. The significantly higher-fractured base at the north-east and the north-west view is reflected in the higher medians. The median finally decreases continuously from north-east, north-west, and south-east to south west, the latter having the largest ratio between smooth facade and windows.

Compared with the smooth cubic buildings, it is striking, that the results are similarly high, at least for

Figure 5
Results for timber constructions and conversions of existing buildings



a certain range of scale. This leads to the conclusion that the differences in visual complexity do not depend upon the fact whether the building belongs to the group of cubic buildings or of classic villas.

Timber construction

Among the analysed buildings timber constructions achieve the highest values (figure 5: Khuner and Müller). These wooden constructions already announce a tendency towards later modern movements (Hitchcock 1994). A stone plinth of the Khuner country House serves as a base for the wooden construction with a flat sloping gable-roof, an appropriate roof for the pre-alpine area. Constantly high results of the measurements are due to the design-related pattern of smaller elements from the windows to the exposed wood trunks (blockhouse). At the same time, the number of components increases when their size decreases - from the whole over larger cuts over windows and finally to the timber structure. Inside, following the *Raumplan*, the two-storey living hall, providing access to the bedrooms via a three sided gallery, is the centre of the house. This is displayed to the outside via a large window front.

The outer appearance of the House project for Dr. Müller's daughter, also called "the last House" (Risselada 1988), is characterized by the separation of the individual layers of wood parts. This again leads to a steeper data curve in the log-log graph. All results of timber constructions are of similar height (figure 5) and have a similar scale range. The only exception concerns the south facade of the house project, due to the outer smoothly plastered chimney.

Conversion of existing buildings

The existing structure strongly influences and limits house rebuilding, especially on the interior and extensions. While Steiner House and Scheu House only have a flat space sequence, Villa Mandl already includes a two-storey hall. However, Strasser House with different spatial levels is finally one of two conversions that featured *Raumplan* for the first time (Risselada 1988). Reconstructing the staircase opens up spaces from intermediate landings. Additional elements, for instance bay windows, loggia and a round tower, dominate the completely redesigned outer facades (Risselada 1988).

CONCLUSION

The box-counting method is suitable for comparing different elevations. It measures the complexity for a certain range of scales. Contrary to the assumption that a building by Loos is smooth from high to low scale (due to his rejection of ornament) some results underline high complexity in a broad range of scales. This is true for the timber constructions, but also for the classic villa-style architecture. As expected, the wood design results in the highest values because they appear roughest. It is interesting that the depth of scales, the range which offers correlation, is not necessarily different from the cubic ex-

amples. While the first examples of cubic style still have a sharp bend in the data curve similar to the Villa Savoye by Le Corbusier, later ones, for instance Bojko House project, seem to be more balanced. In any case it is obvious that Loos' rejection of the use of (contemporary) ornament does not lead to a uniform expression of complexity. Facades of various degrees of complexity, expressed in the data set, accompany Loos' entire creative period. This shows that Loos' creative power cannot be reduced to any uniform dogma, but rather reacts to different requirements. The recurring classical elements are rather a reinterpretation than an unconditional dedication to an entirely new radically smooth surface design and fit into his entire design concept.

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