

# Computational Generation of Hybrid Façades for a Focal Context

## *The case of Naser-Khosrow Street in Tehran*

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*The purpose of this paper is to use shape grammar methodology to generate contextualized urban façades within the focal context of Naser-Khosrow Street in Iran's capital city of Tehran. The history of Naser-Khosrow Street, which is considered a significant historic urban space, begins in the Safavid period (1735-1501). Yet, the urban history and historical significance of this street have been neglected in recent years. Evidence of a sense of turmoil and incompatibility between the modern and traditional architectural façades featured on the street is easily observed. Against this background, this paper offers façade models generated based on the computational methodology developed by Hadighi and Duarte (2019, 2020) to determine and capture the hybrid expression of European modernist and American traditional styles. In this spirit, the systematic methodology of shape grammar is expanded to the focal urban area of Naser-Khosrow Street to generate new façade layouts referencing the characteristic features of some of the iconic buildings located there.*

**Keywords:** *Shape Grammar; Naser -Khosrow Street, Façade Design, Generating Hybridity*

### **INTRODUCTION**

Naser-Khosrow Street began its history during the Safavid Empire (1735-1501) as a narrow and significant pathway aligned with the main citadel walls of Tehran, which was not yet Iran's capital city. It was not until the Qajar dynasty (1796-1925) that Tehran became the capital, an event that proved to be a turning point in the development and extension of the Naser-Khosrow pathway. During this dynasty, Tehran became an important urban center, and over time new urban organizational structures such as the dis-

trict and the parish developed. On this basis, a new urban texture came into being such that the Naser-Khosrow pathway took on greater importance given that it now flanked the new urban areas of Ud-lajan and Marvi. In this extended form, the pathway became Naser-Khosrow Street and even boasted significant new architectural buildings such as Darolfonon, Shams-Ol-Emareh, and Saraye Roshan. Darolfonon was constructed in 1852, during the second Pahlavi period (1941-1978), to serve as the home to the pioneer of modern schools in Iran. A few years later, in

1861, the five-story Palace of Shams-Ol-Emareh, the highest building in Iran of this period, was erected. In 1894, during the Pahlavi era under Reza Shah's rule, the two-story Saraye Roshan was built for commercial purposes. As Naser-Khosrow was (and remains) a commercial street, Saraye Roshan became an inspirational design for other commercial buildings in the area. However, although the construction of the three buildings spanned 42 years, they all, similar to the overall style of the old buildings on the street, follow the same architectural style. This style is Iranian eclecticism, the base of which is a fusion of hybridity between traditional Iranian architecture and European architecture, which was ubiquitous during the Qajar era. Figure 1 shows the locations of Darolfonon, Shams-Ol-Emareh, and Saraye Roshan on the street. Against this background, Naser-Khosrow Street became a commercial focus given the many activities that took place there. Especially from 1921, when due to a population increase in Tehran and significant economic growth, commercial buildings, especially those used for wholesale services in the center of the city, started to develop. However, in terms of its history, architecture, and urban texture, Naser-Khosrow Street has been neglected in recent years. Perhaps, a lack of appreciation for the street's cultural and historical importance led to the construction of new buildings (built from the late 20th century) on the street with façades that are plainly incompatible with those of the old buildings such as the three briefly described. Modern styles stand in stark contrast with the historic styles on the street. The old buildings are orange brick with horizontal and vertical divisions in the façades; the new buildings are uniform with flat light-colored façades without any additional façade divisions. Where the old buildings have curved details and elaborate carvings, the new buildings almost entirely lack embellishment. Recent modifications rupture the historical site's appearance, with no apparent effort made to achieve cohesiveness between the modern architectural styles and the historical architectural elements of the street. This inconsistency creates a strong sense of visual confusion

along the street's length. Thus, in the present study, a systematic method is proposed to generate façades following the historical spirit of Naser-Khosrow Street while also observing the rules and regulations of the present-day urban context. Thus, this study draws on the computational methodology developed by Hadighi and Duarte (2019, 2020) to describe and recreate the hybrid expression of European modernist and American traditional styles. In the present paper, the proposed methodology is further developed to generate a hybrid architectural façade design for the historical urban texture of Naser-Khosrow Street.



Figure 1  
Left: Location of the corpus on Naser-Khosrow Street, Tehran, Iran. Right: From top to bottom: Darolfonon, Shams-Ol-Emareh, and Saraye Roshan. Photographs from top to bottom taken by Neda Alipour, Pedraam (Persian Wikipedia), and Fulvio Spada.

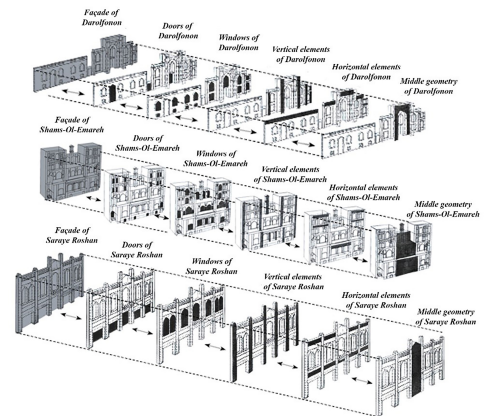
### Shape grammar

Shape grammar is a computational methodology used to describe shape transformations by applying rules to an infinite shape (Gu & Behbahani, 2018). In this procedure, these transformations are illustrated through the schema of  $A \rightarrow B$ , whereas a finite rule is used to convert a left-hand-side shape (LHS) into a right-hand-side shape (RHS) (Gu & Behbahani, 2018; Teboul et al., 2011). The transformation design draws on the grammar to transform existing design styles into new types (Knight, 1983). Examples include Coutinho et al.'s (2011) description of the influence of the historical architecture of Alberti's work on local Portuguese architecture through a shape grammar

and Eloy and Duarte's (2012) development of a transformation grammar for housing rehabilitation to create a new style adapted to contemporary life. The idea of using grammar transformation to establish correlations between classical buildings and modern life culminated in the shape grammar methodology developed by Hadighi and Duarte (2018, 2019) to create a hybrid design. The background of using shape grammar to analyze the existing traditional urban context includes Duarte and Rocha's (2006) study of Medina of Marrakesh through this methodology. Barros et al. (2013) used the methodology to create an adaptive model based on Mapotus's slums in a different direction. A study by Ke (2016), which is currently in progress, will describe the methods used in the grammar in relation to a neighborhood in Beijing, China. The historical importance of the buildings, their development in modern times, and the objective of providing variations of combinations to preserve the local culture are issues considered in this study. In a similar vein, Verniz and Duarte (2017) extended the methodology to describe the complex urban structures of Favela Santa Marta in Rio de Janeiro. In the present paper, the hybrid methodology (Hadighi & Duarte, 2018, 2019) is extended to generate a new hybrid façade solution for the historical urban texture of Naser-Khosrow Street. The idea is to revitalize the traditional urban space by creating harmony between the new façade design and the characteristic features of the street's existing traditional buildings.

Figure 2  
Analysis of façade corpus of Darolfonon, Shams-Ol-Emareh, and Saraye Roshan.

to generate new façade designs; (4) Generate new designs; and (5) Compare the generated designs with the original designs to determine the extent to which the new designs capture traditional elements. The present paper's focus is to generate hybrid façades through the shape grammar developed based on the iconic façades of Naser-Khosrow Street. The grammar-based analysis focuses on a particular architectural design, referred to as a corpus of grammar. The architectural façade design of the selected iconic buildings on the street will be captured in other papers. On this basis, the extracted grammar is extended to generate new façade layouts drawing on the style of existing corpora and modern-world needs. Future papers will focus on related concerns within the larger-scale study.



## METHODOLOGY

The present paper is part of a larger-scale project. Several steps are taken to develop hybrid façades compatible with the traditional buildings on Naser-Khosrow Street and its contemporary needs. The steps to take to achieve that goal are as follows: (1) Analyze the characteristic features of the façades of iconic buildings located on the street; (2) Capture the rules of and develop a grammar for selected façades on Naser-Khosrow Street as the corpus of the project; (3) Develop the extracted gram-

### Analyzing the selected buildings

In addition to an analysis taking into account the corpus's façades based on geometrical criteria, factors such as building codes and cultural context contributed to the assessment of the façades. For instance, as the design guideline of the context limits the height of new construction to a maximum of two grades, the grammar is developed for two-grade buildings. In the analysis of the five-story Shams-

Ol-Emareh, an exceptional building that exceeds the two-grade limit, the whole façade was fractioned into three separate horizontal sections. Analyzing the cultural context revealed that the need to prevent visual access into the building's interior from the outside is a significant consideration in the façade designs. This consideration constituted an important parameter even a limitation, for the design in relation to the configuration of architectural elements such as the kinds of openings that could be included. As an example, even for a very large unit, a sizeable continuous window could not be considered as it would not accord with the site's cultural criteria. Therefore, based on the cultural context, the windows were grouped into three major classifications for the analysis: clerestory, standard, and basement windows. The clerestory windows were categorized as either circular or square edge. The standard windows were defined as one of three distinctive shapes: square edge, top round arch, and top pointed arch. Figures 2 shows the façade analysis of Darolfonon, Shams-Ol-Emareh, and Saraye Roshan.

### Extracting the grammars of the selected buildings

The focus at this stage is deriving rules, referred to as the corpus, from the selected buildings. The derivation process is further categorized into two sets of principles—a lower-level grammar focused on organizing the architectural elements in each unit and a higher-level grammar focused on arranging the fundamental units (Barrios, 2005). The combination of the lower- and higher-level grammars results in the step-by-step derivation of each building's façade. Figure 3 shows the step-by-step derivation of Saraye Roshan.

### GENERATING NEW FAÇADES FROM THE EXTRACTED GRAMMARS

When the corpus's grammar has been extracted, the next step is to generate new façade design solutions through a derivation strategy (Mohamed, 2005). This process paves the way for an architect to design a new façade design for the local context of Naser-Khosrow Street. At this stage, the architect is equipped with possible computational solutions for

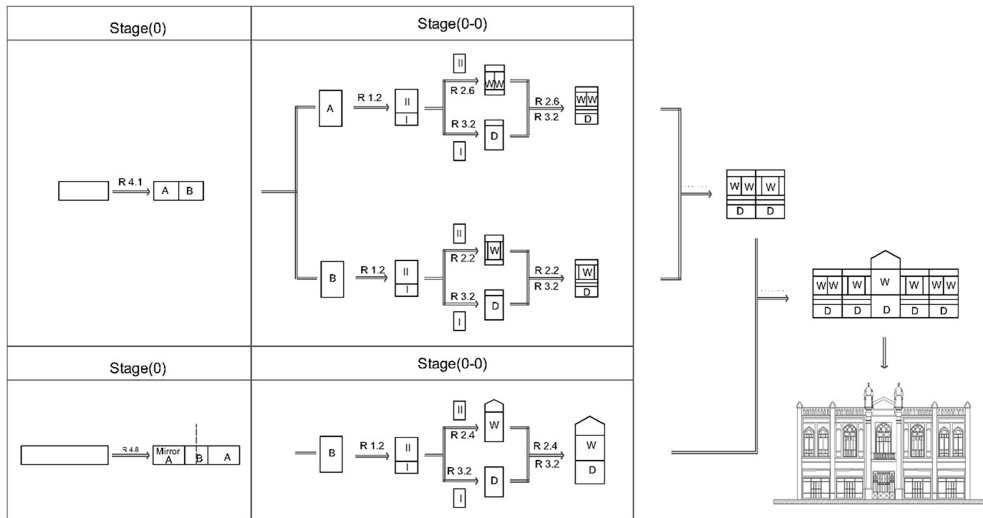


Figure 3  
Step-by-step  
derivation of Saraye  
Roshan.

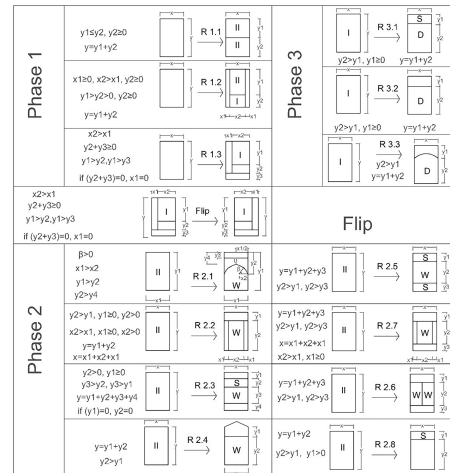
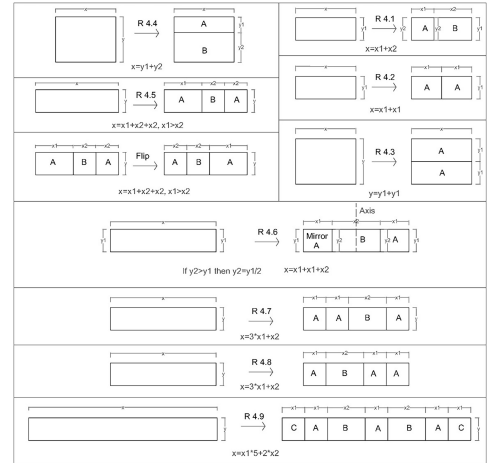
new façades on the street, making it possible to organize a new façade composition following the corpus style. (e.g., Chase, 2002; Ruiz-Montiel et al., 2013). Thus, the generated grammars reflect the historical themes of the site. Given that this is the case, the iconic buildings' influence might be expected to be conspicuous in the corpus. However, the generated façade is new, reflecting those themes but not replicating them (e.g., Knight, 1994; Moon, 2007). Like the extraction process, the generation procedure is executed via a two-step process. In the first step, the split parametric grammar rules are applied to the initial shape to split the basic shape into a wedge of fundamental units. The split parametric grammar is a specialized type of grammar with split rules for a basic shape (Wonka et al., 2003). The rules in this step are drawn from the rules of the derivation process, whereas the configuration of fundamental units in the corpus is defined through the higher-level grammar. In Figure 4, the proposed rules for splitting the basic shape to generate new fundamental units are presented through a parametric split grammar.

Figure 4  
Selected rules of stage (0).

The next step in the generative process follows the rules of the lower-level grammar in the derivation process. In this step, applying respective rules to the fundamental units generates the façade, and the application rule schema is defined through the parametric grammar (Figure 5). In phase 1, labels I and II are generated from the initial shape. In phase 2, II transforms into W for windows and S represents clerestory which are small windows near the roof. In phase 3, I transform into D, the label for a door and small windows above it. In parametric grammars, the layouts of the shape transformation are defined through variables and equations. Ultimately, defining the generated rules results in possible solutions for generating new, thereby providing a multiple-decision diagram from which architects can select a façade that corresponds to their design strategy. The shape grammar of the two generated façades is illustrated in Figures 6 and 7. In Figure 8, the generated façade, and the historical façade of Saraye Roshan are illustrated. In this comparison, the compatibility of the generated

Figure 5  
Selected rules of stage (0-0).

facade with the existing façade of Saraye Roshan is evident based on proportion, division of façade elements, and geometry.



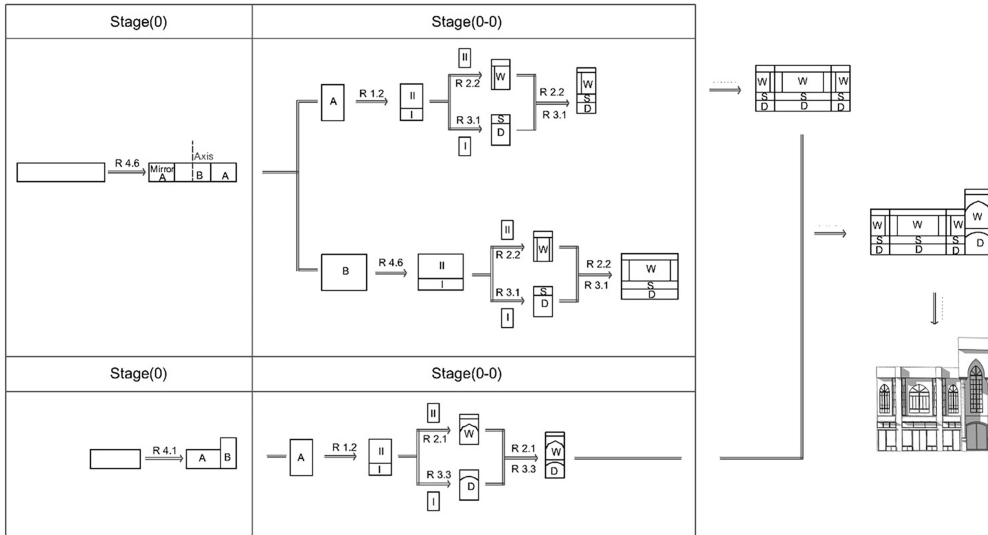


Figure 6  
Generated façade  
through shape  
grammar  
methodology.

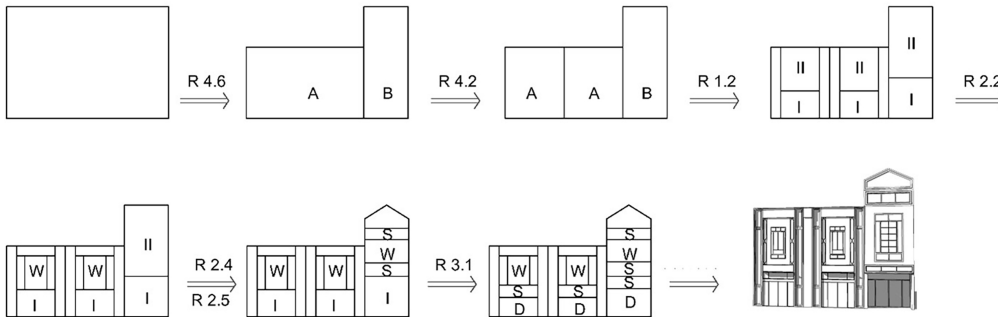
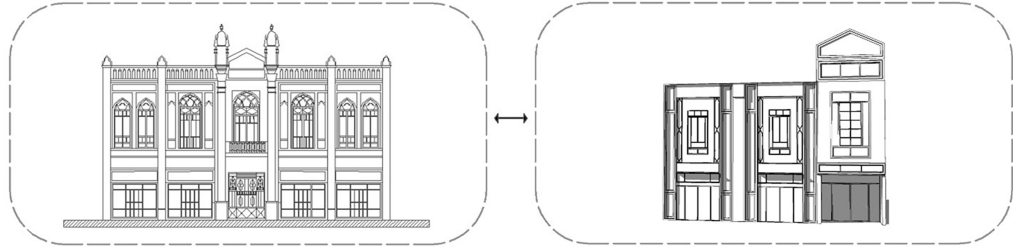


Figure 7  
Generated façade  
through shape  
grammar  
methodology.

Figure 8  
Fig. 8. Generated façade compatible with the existing façade of Saraye Roshan.



## CONCLUSION AND FUTURE WORK

Shape grammar was explored as a computational design methodology relevant to the façade language of three iconic buildings on Naser-Khosrow Street in Tehran, Iran. This exploration resulted in obtaining a grammar schema for each selected façade and presenting a derivation tree diagram as a computational solution for generating new façade designs. This strategy constitutes a useful tool for creating unlimited new hybrid façade designs for Naser-Khosrow Street's urban context and can be applied to historic neighborhoods elsewhere. This process facilitates the creation of numerous façade variations from which the architect chooses the design most appropriate to and expressive of the needs of a given site and the design challenge overall. However, the optimization of the generated façades will be covered in future studies focusing on establishing parameters to guide the architect's selection of a design from multiple options. The purpose of the continuing research project is to analyze the existing façade architecture of Tehran by performing a comparative analysis of the façade grammar of the historical context of Naser-Khosrow Street with reference to and as an influence on the modern texture of Iran's capital.

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