STYLE GENERATIVE TOOL FOR SUAKIN ARCHITECTURE

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ABSTRACT

Suakin architecture is ambiguity in creative nature. Suakin architectures with special emphasis to creative design are rich sources of generative mechanism. These mechanisms are remarkable in their architectural rule specification. These are implicated in a variety of architectures including Turkish style, Anglo-Egyptian style, Mamluk style and Traditional style.

This study is carried out to introduce shape grammar framework as one of the generative tools for Suakin architecture. Based on the deductive analysis of a corpus of five traditional styles from Suakin architecture, the extraction and composition of new Suakin plan layout is presented.

The present study gave preliminary insights into the distinct rich source of generative mechanism of styles generated from Suakin architecture.

Key words: generative tool, Suakin Architecture and Shape grammar

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1. INTRODUCTION

Different ways of arranging lines establish different languages of design this procedure is called “shape grammar” and interpreted by procedures called description function. This two determine the link between designing and its description.

Shape grammars were first defined by Stiny and Gips [1], later the formalism was refined by Stiny [2].

[2], define shape grammar as a formal production system, where particular aspects of the design process are represented by form and are defined according to shapes and rules applied to those shapes.

Stiny [3] claims that design is calculating while expanding the meaning of calculation to visual thinking via his theory of shape grammars. The reasoning behind a visual product was described using a grammar-like formalism with a vocabulary, a set of rules, and a series of computations that produced designs as if they were “sentences”.

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According to Stiny [4], there are two types of shape grammar: Standard and Parametric. In the standard type the rule is defined explicitly by a pair of shapes in the parametric rules are defined implicitly by a diagram and Parametric grammar has varied spatial relations.

The use of shape grammar can help architectural designers to visualize several options of design in 2D and 3D, and then we can select one of these designs. Then designers can have more powerful tool in design process.

In this paper, implementation of shape grammar is presented using top-down approach for case study analysis and a bottom-up methodology for the derivation of artifacts.

2. THEORETICAL APPROACH:

Similar to natural language components, architectural language components are: semantics (meaning and context) and syntax (structure and form). Language has its own syntax, that is, it has its alphabet (primitive elements), vocabulary (elements composed from the alphabet, words, phrases and sentences) and grammar (legal composition of vocabulary, rules and operators). These are concepts that could help to eventually enable computers to undertake design tasks on the level of an architectural language.

Shape grammars are concerned with combining words into entities, or sentences, to form a composition. The application of three concepts is necessary to achieve this composition: relationships, rules and grammar.

2.1. The Development of A Basic Grammar Follows Four Steps

- Shape (vocabulary): A shape is built with the basic geometric objects - point, line, face, or cube.
- Spatial Relations: A spatial relation between shapes can be specified by their distance apart, angle of rotation and scaling factor.
- Shape Rules: Each rule specifies how to transform a given shape to produce a new, similar shape according to their spatial relation.
- Shape grammar (Design): A design originating from an initial shape consists of a number of shapes, each of which is deduced with a grammar rule from a shape produced earlier.

2.2. Vocabulary

According to Knight [5] a shape is a finite arrangement of lines. A 2D shape can be drawn in a finite amount of time. 3D can be constructed in a finite volume in a finite amount of time. Shape can contain occurrences of straight or curved lines, connected or disconnected lines, or open or closed lines[6].

2.3. Spatial Relationships

One shape is a sub shape of the second shape if and only if every part of the first shape is only a part of the second shape. That is, the first shape coincides point for point with some part of the second in the coordinate system in which they are drawn.[5]

When two or more shapes are combined to form a new shape, they have a certain spatial relation.
2.4. Shape Rules
A shape grammar is a rule-based formalism. A shape rule has two steps when applied: recognition of a particular shape shown on the left side and its possible replacement shown on the right side.

The defined rule is operational. The arrow indicates an action. The unique feature of a shape rule is that the left and right side are visually considered. As opposed to symbols, shapes can be looked at and seen differently. This is due to their inherent ambiguities.

The rules of a shape grammar generate or compute designs, and the rules themselves are descriptions of the forms of the generated designs.”

2.5. Shape Grammar
A design originating from an initial shape consists of a number of shapes, each of which is deduced with a grammar rule from a shape produced earlier.

3. THE CASE STUDY: SUAKIN ARCHITECTURE
Shape grammar theories have been developed for a number of works, specifically for architectural styles. Among these works are shape grammars for the architecture of The Palladian grammar [7] Giuseppe Terragni [8], Frank Lloyd Wright [9], Lebanese House Shape Grammar [10], Glenn Murcutt [11], Christopher Wren [12], and Irving Gill (J.Gibbs 1981), for the vernacular styles of Japanese tearooms [5], bungalows of Buffalo [13], Queen Anne houses [14], and Taiwanese traditional houses [15], Chinese traditional architecture [16] and for the landscape architecture of Mughul gardens (G.Stiny and W.J.Mitchell 1980), courtyard houses [17], the architectural style of the Yingzao fashi [18],[19], Landscape grammar [20], patio-house [21], architectural style for Siza’s Malagueira houses [22], mamluk madrasa [23], Traditional Malay Long-Roof Type Houses [24], the Palladian grammar (Palladio’s rules of architecture) is earliest of these works notable for being the first architectural grammar which generates villa ground plans in the Palladian style --motivated in part by Stiny’s [3] recent book presents the shape grammar formalism both with respect to its philosophical and formal level and the alleged influence of shape computation on Palladian’s architecture.

According to stiny [25], a shape computation is defined by the application of shape rule in a grammar. At philosophical and formal aspects, shape grammar provides a formal representation that allows designers to manipulate pictorial representation in a natural and infinitive way, without reference to symbolic representation. Indeed, Wittgenstein [26] address the question “what would arithmetic have been like if shape, not number, had been of greatest interest to us?”

This study focuses on the implementation of the modularity rule of architecture of the Ancient traditional houses of Suakin inland city. This is built upon the arithmetic formalism of shape grammar by [27]. With a rule based approach architectural language, a vocabulary element of Suakin traditional style were defined, then this vocabulary elements were transformed into a Suakin shape grammar and finally a variety of Suakin plan layouts were generated.
4. THE ANCIENT TRADITIONAL HOUSES OF SUAKIN INLAND CITY

Suakin is found at the north-eastern tip of the Arabian-African Coastal Region, bordered by Saudi Arabia to the north across the Red Sea and Sudan to the north and west across an oval-shaped island. It is approximately 750 m. long and less than 500 m. wide in size and is almost entirely flat desert plain.

According to several references, Qezar, et al [28], Dirar [29] Salim [30], and Mallison [31], the earliest history of Suakin dated back to three thousand years BC, where it was used by ancient Egyptians on their way to the Kingdom of girl (Punt) in the East Africa to hunt Elephants. Suakin have been the Roman port of Evangelon Portus used by Ptolemy. In the 10th-12th Centuries, Suakin formed a trading point for the Arabs. Suakin gained importance after the advent of Islam and became the Africa’s number one Port which the pilgrim travelled to the holy land Mecca and Medina. By the fifteenth century, it had become a key mercantile center for Mamluk Egypt, attracting Venetian and Indian merchants, who traded there until the Ottoman invasion of 1517. And from then on, into 19th century, it was during the Ottoman occupation that many of the distinctive Coral Building were built and by the 1922, Suakin had fallen into a ruin with the opening of the Port Sudan at Sheikh Al Bargath.

The Coral Buildings of Suakin developed a distinctive art and architectural style, which was applied throughout the coastal (one of the largest in the Africa and Arab Muslim world at the time). Over a long period of time, between (200-300 BC) – (20th 21th AD), It shares specific culture and social values which are embedded in their everyday system of social organization, also had its influence on their architecture as well.

Suakin Architecture is instantly recognizable in the view of its largely predictable standardized, modular and symmetrical nature [32]. The most important legacy of Suakin is in its unique architecture that implements most of the rules of architecture, relying on local materials like locally available coral stones, reefs paved with white lime. Suakin used these coral stones like the burn modular unit, which gave it the shape and white color that reflects the exquisite beauty of wood configuration.

Although, the making of the standardized oriels building of Suakin was not fingerprints in the details but each one of them is a unique work of art with a high artistic value which needs to be preserved.

Suakin traditional style in the majority of its building often consists of one or two floors. Ground floor contains the business and commercials; the shops and stores. Usually the ground floor contains seats for men and used for the reception of guests by the owner of the house, while the first floor comprises of women apartments, bedrooms and everything related to family life and privacy if there is first floor or on a separate majlis and bedrooms for women apartments on the same ground floor. The roof-terraces ("kharjahs") which is the last or third floor often comprise the small room for servants and food preparation.

The characteristic building standards and almost all the rules of architecture were found in almost all parts of the buildings and is repeated from one building to another, the dimensions or measurement of the rooms and stairs, doors, windows and oriels are uniform within close ranges of each other. This uniformity demonstrates great skill in the art and architecture. The idea of standardization in modern buildings is an idea known to man in the twentieth century to facilitate the construction and erection of parts of buildings, which helped in the conceptual analysis of building. This
uniqueness of uniformity, modularity and symmetry are suitable factors for the
application of parametric shape grammar theory which intend to be the focus of this
study.

The common feature of the buildings discussed above was their simplicity of
architectural style. Even after their tracing in modern artist touches [33], their
simplicity has been retained except for the added elements, namely the Moshrobiyah.
This is, however, elaborately designed. Other building techniques were later
developed in coral building construction in the Suakin city.

Another aspect of this coral building is the carefully selected patterns for internal
decoration. This is mostly done in the Khorishid and mihrab of two mosques (Hanafi
Mosque and Shafai Mosque). This could be seen in the bayt shinnawi where [33]
employed simple motif on the interior of the building. The circular, semi – circular
and triangular patterns aptly fit with the Islamic traditional’s simple architectural
style. Another feature of these forms of buildings is the construction of spout, a
drainage device known as rain spout terminal. These can be seen in the plot 22, 40
and khorishid buildings even on the minrab roof of mosques Building.

The architectural features of the old historic buildings of Suakin Inland have long
been altered from coral structures to brick buildings of Bait jedid. But all these
buildings were built on the same feature. In other words, they have not been replaced
to other feature. M.S. Dirar [29] has mentioned that Even the old Suakin Inland
Building of plot (45), built during the reign of the first ruler under the Mumluk
Empire (Al Shajarat Dur), was replaced by the present modern building on the same
and also mentioned by Ahmed Badawi [34].

This Section discusses the evolution and subsequent developments of different
type of architecture in the Suakin city with particular reference to Suakin Inland City.
We have classified the variety of design into the following housing types depending
on the degree of generality of period or era.

The Suakin shape grammar was developed taking into account all different afore
mentioning type. The documentation produced by the following scholars Greenlaw
(1950), [35], [36], and [30] led to the identification of 40 different houses design,
which is listed in table 3. These 40 house type constituted the vocabulary elements of
the Suakin grammar.

5. THE ANALYSIS

5.1. The Red Sea Style

This coastal region has been a home to various civilizations for over five thousand
years and it covers Egypt, Suakin, Massawa, Eritrea and Ethiopia. These territories
belonged to the former Saba Empire except Egypt. The Architecture of the coastal
region, therefore, was still dominated by the sheer use of coral stone as a material for
both construction as well as decoration. The architecture was more Mediterranean in
effect than were the building of Arabian area, the Mashrabiyah architectural element
that was incorporated into the Suakin architecture was the use of breezes catcher,
upon whose entablature rest on the windows. The result of this combination gave the
building a symbiotic character; it became neither Arab nor Mumluk as [30] argued.
Rather the calligraphy and geometric inscription on it gave it an Islamic character.
5.2. Early Islamic Architecture Style
By the year 639 the Arab Peninsula, Persian Empire had fallen and became part of the Islamic state. It had extended from Syria to North India and borders of China and from Caucasus to Zanzibar. Muslim architects succeeded in refining the local building materials and their powerful structural forms to develop an Islamic architecture of exceeding beauty.
Early Islamic architecture is known for its remarkable domes and vaults. Other equally magnificent architectural works are the Suakin of motif of its doors and walls.

5.3. The Ottoman Style
Turkey along with Anatolia was among the former Byzantine territories that were conquered by Islam. Its capital, Constantinople, later became the centre of intellectual and architectural activities, and above all, the Seat of the Ottoman caliphate as Islamic State. It was renamed Istanbul, having consolidated their hold on the territory.

Their dome, 26.5 meters in diameter and 53 meters in height, is the largest dome in Istanbul after that of St. Sophia. The Ottoman architects carried Roman architecture through to a conclusion attained neither by the Romans nor by the Byzantines. The multi-domed architecture became a monopoly of the Ottomans. The Suleymaniyyah mosque in Istanbul consists of more than five hundred domes. In contemporary Anglo-Egyptian building, the Suakin (Plot 16) remains the only structure that bears the Turkish domed architectural feature of Suakins and its burial ground in Suakin.

Ottoman architecture was not confined to the form in Suakin but it covered most of the functional aspect with the unique mashrobiyah. According to [33] states that Suakin is an example of a small Turkish town built between 16th to 20th centuries like other towns situated around the red Seacoast: Massawa, Jeddah, Hodeida, Assat and Mowka.

5.4. The Suakin Traditional Style
The history of the spread of Islam into the sub-Africa continent went as far back as 710 CE just a year after the conquest of Spain. Muslims began to rule Africa in the first quarter of the eleventh century. Suakin, like Egypt and Mesopotamia, had an ancient civilization. The assimilation of local traditions in the sub-continent took rather a slow process due to the nature of traditional buildings which employed excessive use of Islamic principle and symbolic expressions. However, after a long period of trial and error, a synthesis was finally achieved between the two, giving birth to the genius of Islamic architecture. One of the finest examples of early Islamic architecture is the original style of Suakin built in 1199-1200 CE. A complete assimilation was achieved in the 15th and 16th century as displayed in the ottoman style, bait basha in plot and Suakin’s most-magnificent architectural work, the khorishid (Plot 20) which is one of the wonders of the Architecture of Suakin and a great international tourist centre. [33] Describes this great architectural edifice in these words.

“Such is the power of a work of art and Suakin was a very considerable work of many sincere and gifted craftsmen that it can perpetuate the genius of its makers indefinitely.”
5.5. The Anglo-Egyptian Style

The fall of Ottoman in Egypt in 642 AH paved the way for the penetration of the British forces into the Suakin. The British forces allied with Egyptian under ‘Col kitchenette and they reached Suakin in 647-648 AH. Later Col Gordo’ penetrated the Suakin in 666 AH and the following year another commander ‘mumtaz basha came deep into Suakin and surrounding area. Three years later ‘Suakin succeeded in starting the foundation of Anglo-Egyptian, which was later to become the center of the political, intellectual and cultural development of the Sudan [29].

However, two architectural elements from Egypt and the British exerted influence in the region but the former exerted greater influence on the region, particularly after the ninth century. Egypt influence on the Suakin was increased with the former’s incline and subsequent isolation from the rest of the style or feature after 1950, like Beit Jedidi.

The other predominant features of the Anglo-Egyptian architecture are the curved pointed arches, outside terrace, outside staircase and commercial incorporated functions. The best examples are the plot231 Suakin in Marrikas, custom building and post office (Plate 29) and the plot67 Suakin inland.

6. THE IMPLEMENTATION: TOP-DOWN APPROACH FOR CASE STUDY ANALYSIS

The following section of the paper addresses the implementation of the approach. The implementation proceeds in three parts:

- Rules Derivation,
- The Shapes Matrix and
- The Proposed Design of the User Interface, and an architectural example developed out of the matrix of shapes.

6.1. Rules Derivation,

A shape rule has two steps when applied: recognition of a particular shape shown on the left side and its possible replacement shown on the right side.

The defined rule is operational. The arrow indicates an action.

The unique feature of a shape rule is that the left and right side are visually considered. As opposed to symbols, shapes can be looked at and seen differently.

\[
\text{If (condition) } \quad \text{then (action)}
\]

\[
\text{If (LHS) } \quad \text{then (RHS)}
\]

The following Table 1 represents the derived rules for the five case studies in relation to their specific analysis.
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Table 1 shows a typical Optimal Suakin Design rules for a Residential Design written in a table format.

The Table format (see Table 1), for example, provides a more natural way to think about many types of rules. It provides increased clarity and decreased development time and effort in specifying Design logic. The above rules would otherwise translate into the following set of rules.

Writing Suakin Rules in a formalized, executable fashion requires a language for expressing the Design logic. The semantic of rules should be intuitive to a Design user, even if s/he is not trained as a programmer. For example:

```
(cond
  ((< wi (* 0.5 ht)) (setq wi (* 0.5 ht)))
```

<table>
<thead>
<tr>
<th>NO.</th>
<th>SPACE</th>
<th>HEIGHT m</th>
<th>WIDTH m</th>
<th>AREA m²2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MAXIMUM</td>
<td>MINIMUM</td>
<td>MAXIMUM</td>
</tr>
<tr>
<td>1</td>
<td>DIWAN</td>
<td>8</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>DHLIS</td>
<td>8</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>COURT YARD</td>
<td>——</td>
<td>——</td>
<td>——</td>
</tr>
<tr>
<td>4</td>
<td>STORE</td>
<td>10</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>MAJLIS</td>
<td>11</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>KHAJIA</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>DARWA</td>
<td>6</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>HARIM ENT.</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>KHAZANA</td>
<td>7</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>GREAT MAJLIS</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>STAIRS</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1 - shows a typical Optimal Suakin Design rules for a Residential Design written in a table format.
If Diwan width > Diwan Height then
Diwan.application.heights = Declined.

Example: Sample of Design Rule in Auto-Lisp Language
If the width of reception of the building (Diwan) is greater than the height of reception of the building (Diwan) then the width constraint’s application is Declined.

Example: Sample of Rule in Design Rule Language
(defun rules ()
  (cond
    ((< wi (* 0.5 ht)) (setq wi (* 0.5 ht)))
    ((> wi (* 0.8 ht)) (setq wi (* 0.8 ht)))
  )
  (cond
    ((< ft (* 0.05 ht)) (setq ft (* 0.05 ht)))
    ((> ft (* 0.15 ht)) (setq ft (* 0.15 ht)))
  )
  (cond
    ((< wt (* 0.1 wi)) (setq wt (* 0.1 wi)))
    ((> wt (* 0.2 wi)) (setq wt (* 0.2 wi)))
  )
  (cond
    ((<= ht 4.0) (setq rad 0.125))
    (T (setq rad 0.5))
  )
  (if (< ft 0.15) (setq rad (* 0.8 ft)))
); end of rules
Example: Sample of Suakin Design Rule Code.
Table 2. The vocabulary elements for Suakin’s Grammar

Table 2. The shapes relationship for Suakin’s Grammar
The tree of possibility diagram showing the derivation of basic patterns for suakin, suakin prototypes, subtypes and my design concepts metamorphism from suakin original type by applying for locating functional spaces, locating staircase, locating courtyard and extending, marging and dividing primary spaces into secondary space.
7. BOTTOM-UP METHODOLOGY FOR THE DERIVATION OF ARTIFACTS.

THE MODEL OF SUAKIN STYLE GENERATOR IN THE DESIGN PROCESS

Modeling the design process [37], [25] and Knight [38] divided design process into three main levels: Level one, the Conceptual phase, deals with the main configuration of the plan in an abstract form; its masses and their relationships to each other. The user starts by the initial shape, then specifies the orientation of the design and proceeds with the rest of the plan configuration.

Level two, the development or “adjustment” phase where the abstract form is checked for suitability for the architectural program. Zones are translated into spaces with internal relationships; also articulation elements are defined such as corridors and staircases. Changes in proportions and positioning may be introduced whenever needed.

Level three, the detailed phase, where the final form has been developed and other rules or grammars are applied to refine the architectural features, with more details for walls, openings and other structural and architectural elements.

The current work addresses the first two levels of this design process; the configuration of the plan and its adjustment, as it clearly demonstrates the full capabilities of the suggested design creative and generative approach in the early phases of design.

In order to convey the flavor of the work with the proposed approach, a new design using the proposed design generative model for Suakin’s design is presented in Figure 7.

The suakin style generator session starts by defining an initial shape: a point anywhere on the screen.

- A point anywhere on the screen.
- Defining Housing grammar
- Defining general schematic grid dimensions of layout
- Defining the primary space
- Locating Harem and main entrances
- Defining the secondary space
- Dividing the primary space
- Extending functional space
- Locating the circulation
- Defining the openings
- Defining the doors
- Adding the details
8. SUMMARY AND CONCLUSION

This study has implemented the Suakin grammar as to the prototype computational tool of the CAAD rule-based framework as one of the CAAD generative tools. Based on the deductive analysis of a corpus of five traditional styles from Suakin architecture, the extraction and composition of new Suakin plan layout is presented.

The new designs of Suakin styles presented in this paper shows enough flexibility to produce many designs according to the user’s needs but still follows Suakin’s style and this is clearly obvious in our creative design environment. The above prototype system tested, points out the importance of continued research into this subject matter.

REFERENCES:


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Style Generative Tool for Suakin Architecture


