# Using Procedural Modelling as a Framework for Representing Style: An Example from Regency Architecture

Erica Calogero[1], Nick Tyson[2], David Arnold[1] and David Morris[1]

[1]University of Brighton, Brighton, U.K.
[2]Regency Town House, Brighton, U.K.

**Abstract**

*This paper reports the use of shape grammars, as made available in CityEngine, to deconstruct six examples of Regency facades and uses them to form a reconstruction of Brunswick Square, in Brighton & Hove, UK. The aim of the research is to evaluate the potential for shape grammar rules to effectively encapsulate aspects of style in a formal, computational language. It is argued that such a system could both result in a stochastically based definition of Regency style with a measurable degree of certainty and enable the presentation of historical periods of history in a real-time virtual environment.*

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: 3D Graphics & Realism—Virtual Reality K.4.3 [Computers & Society]: Organisational Impacts—Automation J.5 [Computer Graphics]: Arts & Humanities—Architecture J.6 [Computer Graphics]: Computer Aided Engineering—CADalgorithms

## 1. Introduction

This paper reports the use of shape grammars, as made available in CityEngine, to deconstruct six examples of Regency facades and use them to form a reconstruction of Brunswick Square, in Brighton & Hove, UK. The aim of the research is to both evaluate the potential for shape grammar rules to effectively encapsulate aspects of style in a formal, computational language (as opposed to purely mathematical or natural) that can be applied by architectural experts who have little background in computer science and its methods. Such reconstructions can be used for historical research, development control by local authorities/municipalities and for public education and exhibition in the cultural heritage sector. The work takes place as part of a broader effort by 3D-COFORM partners to implement a specific user scenario whereby it is possible, through different software processes, for an end user to view a representation of an historic city in an immersive (or screen-based) virtual environment and to be able to select a time-period to be reconstructed, so that the virtual reconstruction updates itself in real-time to present the user with an historically plausible (or accurate) representation of what the city looked like in that time period.

The example used as a case study is Brunswick Square, a development of 58, classically styled, large terraced houses built between the mid-1820s and 30s, as the centrepiece of architect C A Busby's Brunswick Town Estate, a coherently designed early-19th century new town sited between Brighton and the village of Hove (see figure 5). The advantage of choosing Brunswick Square for a first investigation into this exploration of rule-based style specification is that it is a well-preserved example of an architect-designed Regency urban masterplan based upon the terraced house form. The ability to measure and investigate the buildings will aid the creation of a taxonomy of style that may be applied over a wider area. For example, where contemporary buildings have been knocked down or replaced with newer incarnations.

Architectural style in the 'West' has been written about continuously since Vitruvius [Pol60]. What most people might consider as style would probably be the beauty element of an artefact (Vitruvius's "venustas") and deal with terms such as order, arrangement, proportion and symmetry. While these are issues that this paper will address; style has a broader set of definitions that may still apply in the context of buildings and cities (see [Pri10a]). In particular, there

are three additional interpretations of style that are relevant: the definition of style as a manner or mode of doing or making; that of a vogue or trend; and that of a “way of expressing” a group’s output (be it artistic, musical, linguistic, etc.). The latter category has been encapsulated by Glassie [Gla75] as "the transmission of culture through artefacts", where we take culture to mean all the knowledge, values and ways of doing things of a particular group of people at a place and time in history [Pri10b], with culture encapsulating scientific knowledge and artisan technique which will inform and affect the elements of building style. It is argued here that often context is key to the correct interpretation of the formal rules and numbers that are derived from the translation of a style into a shape grammar.

The remainder of this paper will set out the context and relevance of architectural applications of shape grammars. It will then cover the history of contemporary Regency Brighton, exploring the practices mentioned above that may have brought to bear on the stylistic choices in the design of the square. It will then set out the methods through which the reconstructions were created from pre-processing, survey and analysis to processing. Subsequently, the results of the reconstruction will be presented, and the resulting hierarchies and rule-based definitions of the front facades of the square examined. Furthermore, a discussion of the results will be carried out; along with the current usability issues and limitations of the software. Finally the conclusion will summarize the findings and it will present a program for future research to address the issues highlighted in the discussion.


**Figure 1:** *Ordnance Survey Plan of Brunswick Square (1930)*

## 2. Background

### 2.1. Architectural Applications and Shape Grammars

Procedural modelling has been used in computer graphics since at least the early 1970’s as a means of describing how the elements of form can be composed, for example in architectural applications to meet design constraints. Shape grammars are a particular form of describing the structure of a composition of shapes. As with other language grammars, both natural and programming ones, it describes the ordering of elements within formal hierarchies that conform to a set of rules.

Shape grammars and other procedural modelling systems allow formal components to be assembled so as to meet particular design objectives. Early work in this area with architectural examples include [Yes75], who designed a system founded on rule-based productions which emulated the process of laying out buildings on a site. The SIPLAN (SIte PLANning) system took as input the description of a site and produced as output prototypical layouts in different genres (e.g. high rise, streets or cul-de-sacs). Around the same time [SG72] were using shape grammars in the production of paintings and sculptures. Probably, however, the most comprehensive use of rule-based generation of shapes has been in the use of L-systems to emulate the growth of plants [PLH*90]. More recent examples of complementary approaches to shape grammare and procedural modeling technniques include [BFH05], which presents a trivially parametric system of encoding 3D form.

Whilst the use of shape grammars to generate instances within a particular stylistic family has been investigated for decades, it is argued that the analysis of compositions of shapes on the basis of grammatical descriptions of classes is in relative infancy. Grammars are used both generatively - to create a valid instance within the rules of the grammar - and to analyse a potential instance for its underlying structure and meaning. Shape grammars have the same potential. To date they have been used more as a way of describing how instances can be generated, but the thinking behind defining a grammar provides a basis for understanding the rules of composition and the common characteristics of compositions within a generic style. This is an example of the influence of "computational thinking’ in analysis, which is the subject of a growing realisation of the importance of computer science to other disciplines. The key contribution of the paper is, therefore, to set up the framework for a representational language that allows a more systematic and effective analysis of the elements of built architectural style.

Modelling "what will be" is different from compact description of "what is" or constrained, evidence-based modelling of "what was". Luc Van Gool’s group at ETHZ have used similar shape grammar approaches and adapted them in the EPOCH project to make them work to demonstrate constraint-based modelling of what was, based on the existing evidence in the form of building footprints.

For many years procedural modelling and the use of subdivision surfaces has also long been recognised as providing an analytical basis for decisions about the level of detail to be included in the real-time rendering of complex scenes.

By analysing the essential components of the structure of the model of an environment, decisions can be taken about the level to which a rendering engine must elaborate the detail both in order to achieve reasonable image quality and to maintain display refresh rates, which is essential to avoid breaks in presence for the user of a real-time virtual environment. As the rendering power of graphics engines continues to develop, shape grammars have great potential in informing the decision making of these procedural methods whilst allowing very compact, parameterised descriptions of environments.

Analysis of architectural style in terms of shape grammars is therefore expected to inform both the design of tools to assist in the analysis of archaeological evidence and of systems to provide real-time visualisations of massive virtual environments of architectural heritage. Examples of such an approach are presented in [MVW*06], and [MVUG05]. However uses to date are largely unvalidated in terms of historic accuracy or the degree to which they are able to capture sufficient detail of period features that are essential characteristics of particular styles, and to use the systematic encapsulation of building facades to aid the category definition of an architectural style. The research in this paper is being undertaken to address this gap - by analysing a particular period of architectural style that seems well suited to treatment as a shape grammar and attempting to reproduce instances of architecture within that style which can be measured against existing, well preserved, architectural heritage. This allows the efficacy of the approach to be analysed in order to tackle the remaining challenges to be met by research in the field.

### 2.2. Regency Town Planning and Building Practices

As mentioned in the introduction, understanding a little of the social, economic and cultural practices of those who produced the artefacts under study may provide a useful basis for the development of parameters and constraints in the definition of the shape grammar. Often, without knowledge of the historical context of an architectural style, the formalisms are either harder to generate or harder to interpret. To this end a brief history of Regency town planning and building practices follows.

According to Watkin [Wat82], the Regency urban plan responded to the rapid expansion of English and Scottish towns at the time, the developing Empire and concomitant increase in trade impacting on the mercantile classes, spreading wealth and swelling population. Moreover, Watkin attributes the industrial revolution as a cause for increased demand for new housing, chiefly via the creation of jobs and money from the technological innovations in textiles, energy and iron. He cites, London, Brighton, Cheltenham, Clifton (Bristol), Newcastle and Edinburgh as cities that were all transformed by terraced, Regency developments that are similar in plan to our cases study square (see figure 1).

Watkin argues that the origin of the Regency terrace lies in the work of Edward Shepherd in Cavendish Square, London (1720), John Wood the elder & younger in Bath (1729-75) and that earlier examples are only to be found in France (J.H. Masart in Place Vendome, Paris in 1690). These are all examples where the terrace is to be read as one unit, with ordered symmetries of ornamentation that spanned the entirety of the terrace facade.

Muthesius [Mut84], however, claims that the birth of the terraced house form predates the Regency period (1790s-1840s) by well over a hundred years, first appearing after the great fire of London, when large swathes of London were rebuilt. Perhaps these earlier forms did not encompass the notion of terrace-as-palazzo as interpreted by Watkin nor maybe the comprehensive town-planning approach that is key to Watkin's notion of the Regency model. However, the terraced house as a form can still be seen as a relatively stable building typology that answered the social and cultural needs of the British population long before the individuation of a proto-Regency trend for global masterplans and facade orders; and, he claims, was only banished from development practices in the period between the 1890's and the 1970's.

At any rate, where the Woods' early Georgian work in Bath shows a great deal of homogeneity and restraint in the use of ornament, by the time Brunswick Square is being built, the Regency flair for pomp, circumstance, variety, and disregard for the rules of the classical cannon are evidenced to a large measure in Busby's designs. Here the influence of the Picturesque that Watkin cites in the design of Regent Street, the "deliberate breaks in ... composition and silhouette" [Wat82], are taken to another level by Busby in the Brunswick Town master plan.

Such town planning and building practices inform the very shape and nature of all regency terraced houses, including those to be represented in this paper, as they influenced, among other things, the building plot layouts, shape and proportions of the housing produced. However there were also specific conditions in Brighton that influenced urban form.

### 2.3. The General Development of Brighton to the end of the Regency Expansion

Until the mid-18th century, Brighthelmstone (Brighton) was largely contained within West Street, North Street and East Street, which formed three sides of a square bordered to the south by the sea.

Kaminski [Kam10] explains the growing demand for temporary accommodation in mid-18th century Brighton as being due to the emerging interest in seawater as a medical cure and in the increasing popularity, amongst the upper classes, of escaping the City for a "social season". These trends, evidencing Brighton's early status as a popular destination spa resort, brought with them an associated visitor housing pressure that was initially met from within the boundary of the

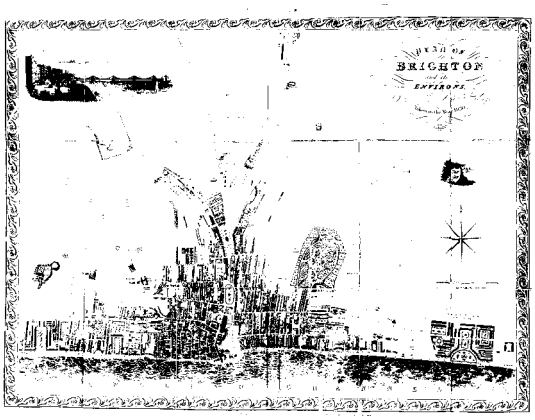


**Figure 2:** *A Map of Brighton in 1830 by Cross*

old-town. Once this capacity was filled, however, development spilled out beyond the cardinal streets. First to be transformed were lands to the north of the town, where previously there had been a market gardening industry and to the east, (the area of the Steine) where the needs of fashionable society to promenade caused the displacement of local fishermen, who had previously used the space for commercial purposes. Later in the town's development, building works also evolved to the west. Berry [Ber05] notes the difficulty in Brighton for developers to purchase land in large enough pieces for development, due to an archaic system of land partitioning into "paul pieces". This, she claims, nay have contributed to the particularly narrow block widths that ensued, often with a street and a row of houses comprising the sum total of any one developer's contribution to the urban plan. This analysis evidences how the growth of the street pattern during the Regency period was as much influenced by patterns of ownership of the underlying plots of land as by formal principles of urban planning.

Of course, stylistic considerations imposed themselves on the designs employed for individual properties and for terraced rows, as would be expected. This leads, in the late-Regency to the full panoply of design themes associated with the period, classical, Gothic, Italianate, Mogul, etc. In addition to these factors and those noted above in the previous paragraph, however, the building procurement and construction processes also shaped development.

Berry [Ber05] [Ber09] and Bingham [Bin91] set out the contemporary practices in this regard; and, like Watkin, they emphasise the speculative nature of urban development at the time. This process allowed men of relatively limited financial means to operate alongside others controlling extensive resources so that both could engage in house building during the speculative bubbles of the early-19th century. The combined financial input of the many managed to complete what, for any one player, would have been far too expensive. The basic principles of the speculative process could differ with the scale and quality of project to be completed but is distilled below.

The way of ensuring the quality and consistency of visual-style and material-construction was principally through the use of architectural drawings and legal agreements - often restrictive covenants instigated with the first sale of the building plot to a future builder, developer or owner. On a low-end project the design element might be met by a pattern book solution [Bus08] whilst within an up-market development an architect might contribute the design.

Sometimes, and more especially in small-scale, less prestigious, projects, there was a relaxation of, or complete failure to introduce any, restrictive covenants or other forms of governance. This is Berry's explanation of the visual variety of Regency terraces in Brighton, in contrast with those of Bath and, more locally, Brunswick Town and Kemp Town. Another important factor in the enforcement of covenants is that they were sometimes dispensed with during difficult economic times to assist speculators in avoiding bankruptcy.

So, on the one hand we have the stylistic exigencies of the period (in the conventional sense alluded to in the introduction) that partially account for building layout and facade design. On the other, the real and practical constraints on the developers of Regency Brighton, constraints that included fragmented plot ownership, the ensuing purchase and transaction costs, legal restrictions imposed by lead developers and the impact of the economic cycle. All of these played their part in determining the urban morphology of the town and impacted on an otherwise topologically stable building form: the terraced house.

### 2.4. The Development of Brunswick Square

Brunswick Town was a super-sized speculative opportunity, most likely conceived of by the architect C. A. Busby. Its development was certainly planned and overseen by Busby; who contributed the design talent, management skills and project oversight required; and was supported by the owner of the land upon which it is built, the Reverend Thomas Scutt, who was the primary financial beneficiary. Scutt was, seemingly, otherwise, a backseat partner; responsible only for providing the land and the seed money used to start the development.

The estate was begun in 1824 and the majority of the more significant buildings were completed by 1834, when Busby died in his late-forties. Brunswick Town was amongst the very largest of construction initiatives to occur in Regency Brighton & Hove and involved developing properties designed for differing uses and of different sizes; to meet the needs of people and businesses in the different social and economic sectors of society.

Being architect-led, the project was somewhat unusual

for its time, when much local development still proceeded without professional input. It is also worthy of note that the project occurred outside of the parish of Brighton and its five laines, on land slightly further to the west within the Parish of Hove. Given this, some of the development challenges referenced in the previous section were of apparently little concern. For us today, the Brunswick initiative represents, in many ways, a microcosm of Regency urban development and a worthy exemplar project of its age. Busby and Scutt governed their development via the use of architectural drawings, restrictive covenants, and 22 key building regulations covering topics such as colour, materials-quality, relational-dimensions, etc. Investors buying into the scheme would have agreed to meet the imposed conditions.

The speculative process and the wide range of properties to be built meant that men of hugely varied means could participate in the development. Those with relatively little resource focused on developing the smaller sites in the side streets of the new town. Local and national figures with greater funds, such as Sir Robert Cunningham and Charles Elliot, risked their investments on the development of Brunswick Square and Brunswick Terrace properties.

The standard practice was generally for a gentleman speculator to purchase their holding and then employ a builder to complete the work. Occasionally, an investor was commissioning their own home, as was Sir Robert. There were also instances of local builders, such as Cooper & Lynn, having sufficient financial resources to speculate directly. Only rarely would investors build more than a few houses before attempting to sell or rent their holdings - the proceeds of their efforts then often being put back into further development opportunities. Without the problem of fragmented ownership of land, and benefiting from the guiding hand of a professional architect, Brunswick would appear to have offered every prospect of a Regency development that should have been completed as planned. Yet, despite its apparent advantages, various issues and pressures caused Busby to oversee a project of surprisingly mixed and regularly altered design.

In some cases, the mix stemmed directly from Busby's wish to reflect his design skills by combining mixed individual facades within in a single palace composition. Other causes of variation were less planned and necessitated alterations of Busby' original ideas. Among these were two principle reasons. Firstly, approaches were made to Scutt by some developers for the right to construct larger properties than Busby had envisioned. This necessitated the scaling-up of certain architectural facades and the introduction of other new ones to remedy problems caused within the span of terraced sections. Secondly, a downturn in the economic cycle resulted in Busby relaxing both design and materials regulations, so as to help investors escape the challenges of the speculative process without facing bankruptcy. Albeit for some, including Busby himself, the vagaries of the development cycle would ultimately lead to this.

All of these pressures, and indeed just simple human error during the construction process, caused a surprisingly, and delightfully, varied outcome within what, on first analysis, would seem to be a stable development environment. Many of the variations encountered due to the above reasons are well suited to be parameterized using shape grammars. Irregular plot widths, changes in ornamentation and differing global facade layouts are easily treated within the following methodology. It is also one of the key benefits of taking this approach with buildings that still exist and for which we have complete information.

## 3. Methodology

### 3.1. Pre-Processing, Hardware & Software

The software used to create the procedural models was CityEngine 2010.1 PRO (Microsoft Windows Edition) running on a dual core 64bit 2.2Ghz computer with a NVidia GeoForce 7800 GTX graphics card. Ordnance Survey's MasterMap map data was used to obtain the initial building plot outline polygons. These were imported into CityEngine as .obj files once the polygon vertices had been re-ordered manually. Such a procedure was necessary in order to render the orientation of the buildings readable to the software. In this instance, it required that the first edge of the outline polygon was reset to represent the front facade; as later on this ordering would be relied upon to generate the front facades in the correct orientation.

### 3.2. Surveying

In order to obtain the correct proportions of the key facade elements, measurements were taken from no. 13 Brunswick square. This is a publicly accessible building belonging to the Regency Town House Trust. Standard survey tools and techniques were used (laser distance meter and tape measures) to measure window and door dimensions; floor to ceiling heights; floor and wall thicknesses; and ornamentation proportions and arrangements. Photos were taken of each of the facades fronting Brunswick Square and composed into rough elevations for the purpose of visual analysis (see figure 3), which allowed for their categorization into types by visual inspection. One photo for each of the facade types identified was then rectified in Photoshop. Window aspect ratios from the physical measurements taken were then used as a rough guide to stretch the rectified photos manually into a more scale-consistent representation. This facilitated taking those dimensions that were not measurable on site from the stretched, rectified photos (see figure 4).

### 3.3. Processing

Once the facade types were identified and classified, each facade type was first described in words, then visually seg-

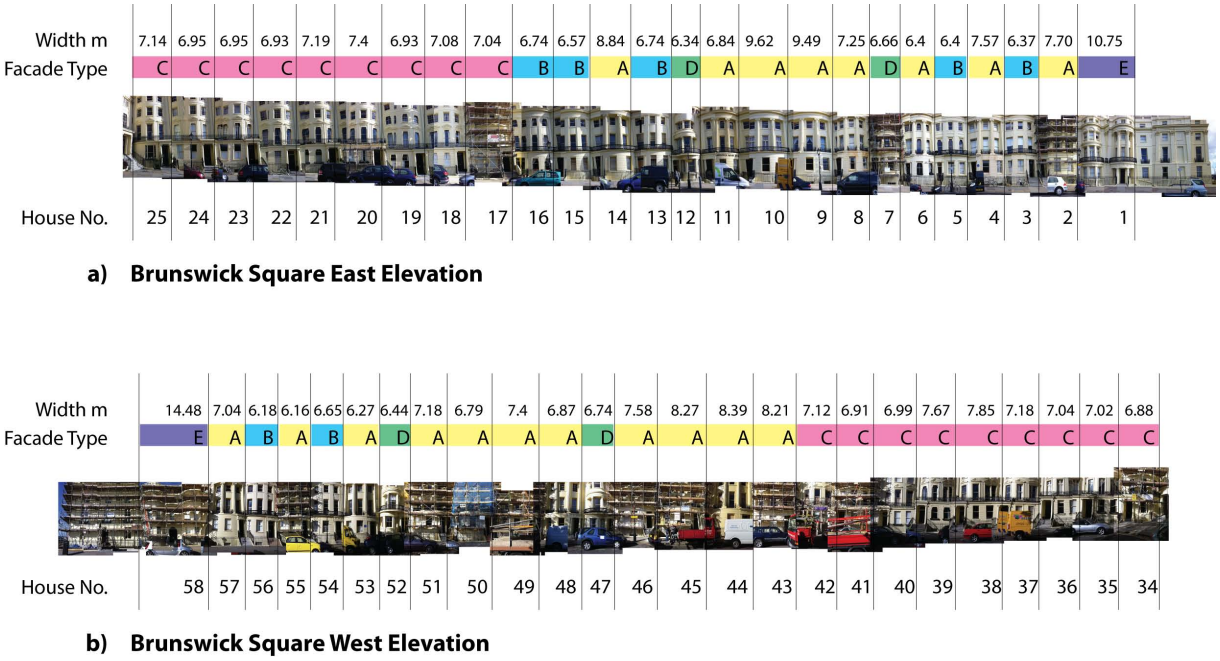


**Figure 3:** *The Distribution of Facade Styles in Brunswick Square*

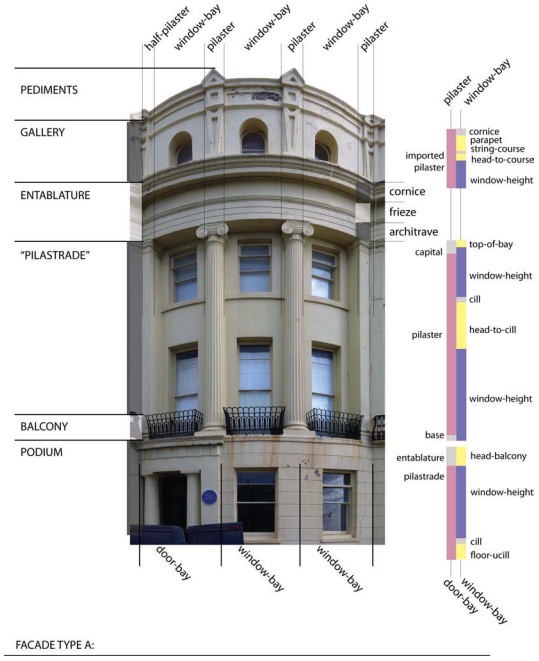


**Figure 4:** *Diagram of Splits for Facade Type A*

mented into hierarchical grammar splits (see [WWSR03]) down to 3 levels in the hierarchy (see figures 4). This visual break-up of the facades served as a guide to create shape grammar rules (.cga) for the buildings on the square.

In order to visualize the buildings in 3D using the .cga rules. the reordered MasterMap polygons were extruded to create a single volumetric shape, and then each face of the volume was identified as either roof, front facade, or "other". In the case of roof or front facade, different rule files were called to further elaborate the design, or in the case of "other" were terminated. The first level of grammar was therefore a global template for the whole of the square and adaptable to any regency terraced house. It was at this level that the buildings were customized to account for their stylistic variations (planned or unplanned); and where the the assignment of "'styles"' could be carried out using either the random functions within CityEngine or from the attached GIS database.

The modular rule files created for the reproduction of the square included one module for each facade type; and modules for different window, door, roof and architectural ornament types. Such modules will be useful as the start of a style library that can encompass other exemplars of buildings from the same or different style category or period. At the same time, however, it allows for the creation of a unique fingerprint for each house depending on the combination of modular elements that need to be accounted for in the streetscape. Such fingerprints can ultimately be fine

tuned with the inclusion of the physically surveyed dimensions as parameters or "attributes" within the rule files as and when such data becomes available. It is worth noting at this point that complicated and curved geometries of ornamentation or layout were hand modelled in Rhino and imported into the grammar either as terminal nodes or as a basis for further splits.

| Type | # Buildings | % Buildings | % Cumulative |
|---|---|---|---|
| A | 19 | 38 | 38% |
| B | 7 | 14 | 52% |
| C | 18 | 36 | 88% |
| D | 4 | 8 | 96% |
| E | 2 | 4 | 100% |
| Total | 50 | 100 | 100% |

**Table 1:** *Summary of Facade Type Distribution on Brunswick Square*

## 4. Results

The houses on the square can be categorized into 6 styles of facade for which rules were devised to generate a replica of the originals. As can be seen in table 1, 74% of the houses on the square are represented by 2 of the 6 identified facade styles (types A & C).

The average plot width of the buildings, as measured from the Ordnance Survey plans, is 7.38m, with a standard deviation of: 1.366m, a max of : 14.48m and a min of: 6.16m. Such variation, though not uncommon, was particularly pronounced due to the developers' exigencies cited in section 2.4. Most of the buildings are 4 or 5 storeys, not including basements, which are ommitted in this paper.

It was discovered that there were 3 fundamentally different ordering principles within the 5 facade categories. Facade types A & B shared the same overarching facade hierarchy. This was one of a global, vertical split into which decorative elements were defined. This preceded subsequent splits necessary to individuate different floor levels.

In contrast, facade types D & E showed an overarching horizontal split into 3 or 5 vertical segments into which protruding bays were alternately inserted. Subsequent splits were by floor, then aperture and decoration.

Finally, facade type C was the simplest hierarchy, with all decoration ocurring at window, door or floor level, such that the primary facade split was into storeys. This is closer to the modern paradigm of facade design. It is also noted that the reason for the simplicity may have been the stylistic influence of Sir John Soane and other figures in the architecture wolrd, or purely for financial exigencies.

Window height-to-width ratios varied on the face between 1.14 on the top floor (nearly square) to 3.1 on the first floor french windows. Floor to ceiling heights varied from 4m to 2.5m, with the highest ceilings on the two public entertaining floors: the ground and first, whereas the floors for sleeping accomodation and servants' quarters were much lower. This combination of tall ceilings and stretched vertical windows, decreasing in slenderness and height with increasing distance from the ground, serves to exaggerate the visual perspectival shortening that would anyway occur, re-inforcing a verticality which is used both in the hierarchical ordering of the social lives of the inhabitants and in the sylistic appearance of the facades.

At this stage, details such as the design of capitals, complex pilasters, stone and cast-iron balustrades have been inertly modelled in regular CAD, so analyses of the proportions and internal ordering anf arrangement could not be carried out.

## 5. Discussion

Categorizing facade types and using shape grammar rules as provided by the CityEngine software allowed for a reasonably accurate and plausible reconstruction of Regency townhouses in Brunswick square (see figure 5). Such a reconstruction contains enough detail for public education and dissemination and also provides a good representational framework for the insertion or integration of more detailed representations provided through other means. Such representations may be hand drawn construction details or high resolution scans using time-of-flight or photogrammetric acquisition techniques.

The limits of shape grammar representation, as implemented in CityEngine are the lack of ability to parameterize more complex, curvilinear shapes. This is worked around by the importing of terminal CAD geometries. However future work will address this by developing a means to import GML created objects [Gen10], which have intrinsically parametric qualities. Another limitation of the shape grammer representation of architecture is the strictly hierarchical form of the generated structures. Such tree-like hierarchies have already been criticized in urban planning practices [Ale74], as unrealistic form of representation, which fails to capture the richly interconnectedness of socio-spatial systems. The same argument can be made for buildings here, where a more flexible graph representation would provide a more powerful form to represent complex architecture and its meaning. Future work therefore will also encompass defining a basic building ontology that will adapt to the complexity of the building descriptions generated. A window is not only part of a facade, but also of a room.

## 6. Conclusions

The exercise of encoding shape grammar rules that would replicate the regency town houses of Brunswick square also provides the opportunity to deconstruct the formal elements of regency style within the limitation of the representational

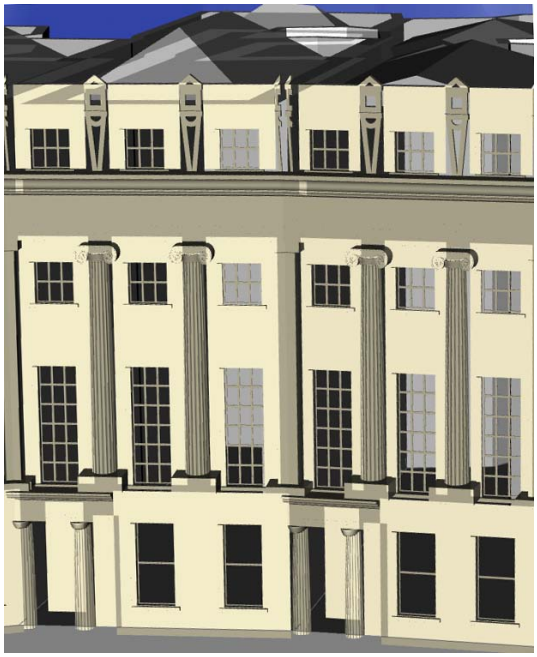

**Figure 5:** *Reconstructed Facades from Brunswick Square*

framework provided by shape-grammar-type descriptions. While not enough evidence was collected to make any significant, systematic, experimental conclusions about what constitutes Regency style (as represented in shape-grammar terms and espoused by CityEngine); it is possible to envisage the collection of a larger sample of buildings, with their key measurements and encode a stochastically based definition of Regency style with a measurable degree of certainty.

## References


[Ale74] ALEXANDER: *A City is Not a Tree*. Unknown, 1974. 7

[Ber05] BERRY S.: *Georgian Brighton*. Phillimore & Company, 2005. 4

[Ber09] BERRY S.: Thomas reed kemp, the shaping of regency brighton c1818-1845. *Georgian Group Journal 17* (2009), p125–140. 4

[BFH05] BERNDT R., FELLNER D. W., HAVEMANN S.: Generative 3D models: a key to more information within less bandwidth at higher quality. In *Proceedings of the tenth international conference on 3D Web technology* (New York, NY, USA, 2005), Web3D '05, ACM, p. 111âĂŞ121. ACM ID: 1050508. 2

[Bin91] BINGHAM N.: *C. A. Busby: the regency architect of Brighton & Hove*. RIBA Heinz Gallery, 1991. 4

[Bus08] BUSBY C. A.: *A Series of Designs for Villas and Country Houses Adapted with Economy to the Comforts and to the Elegances of Modern Life with Plans and Explanations to Each*. The Architectural Library, 1808. 4

[Gen10] GENERATIVE MODELLING LANGUAGE:. http://www.generative-modeling.org/, December 2010. 7

[Gla75] GLASSIE H. H.: *Folk housing in middle Virginia: a structural analysis of historic artifacts*. Univ. of Tennessee Press, 1975. 2

[Kam10] KAMINSKI J.: No lodgings to be for love or money: the business of accommodating visitors in eighteenth century brighton. *Sussex Archaeological Collections 148* (2010). 3

[Mut84] MUTHESIUS S.: *The English terraced house*. Yale University Press, 1984. 3

[MVUG05] MUELLER P., VEREENOOGHE T., ULMER A., GOOL L. V.: Automatic reconstruction of roman housing architecture. In *Recording, modeling and visualization of cultural heritage* (2005), p. 287âĂŞ298. 3

[MVW*06] MUELER P., VEREENOOGHE T., WONKA P., PAAP I., GOOL L. V.: Procedural 3D reconstruction of puuc buildings in xkipche. In *Eurographics Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST)* (2006), p. 139âĂŞ146. 3

[PLH*90] PRUSINKIEWICZ P., LINDENMAYER A., HANAN J. S., FRACCHIA F. D., FOWLER D. R., DE BOER M. J., MERCER L.: *The algorithmic beauty of plants*. Springer New York, 1990. 2

[Pol60] POLLIO V.: *Vitruvius*. Courier Dover Publications, 1960. 1

[Pri10a] PRINCETON UNIVERSITY: "about wordnet." wordnet. http://wordnetweb.princeton.edu/perl/webwn?s=style&sub=Search+WordNet&o2=&o0=1&o7=&o5=&o1=1&o6=&o4=&o3=&h=00000000, December 2010. 1

[Pri10b] PRINCETON UNIVERSITY: "about wordnet." wordnet. http://wordnetweb.princeton.edu/perl/webwn?s=culture, December 2010. 2

[SG72] STINY G., GIPS J.: Shape grammars and the generative specification of painting and sculpture. *Information processing 71* (1972), 1460âĂŞ1465. 2

[Wat82] WATKIN D.: *Regency: a guide and gazetteer*. Barrie & Jenkins, 1982. 3

[WWSR03] WONKA P., WIMMER M., SILLION F., RIBARSKY W.: Instant architecture. In *ACM SIGGRAPH 2003 Papers on - SIGGRAPH '03* (San Diego, California, 2003), p. 669. 6

[Yes75] YESSIOS C. I.: Formal languages for site planning. *Spatial Synthesis in Computer-Aided Building Design (Ed. CM Eastman). Applied Science Publishers Ltd., London* (1975). 2