Recognizing architectural representations

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The paper presents an overview of mechanisms underlying architectural perception and recognition. These include both general perceptual principles and specific domain constraints. The former determine the objective identification of elements and relationships in any visual scene, while the latter make architectural styles recognizable even to perceivers without extensive acquaintance with architecture. This is because many of the architectural constraints underlying a style have a firm foundation in general principles.

Keywords*: Representation; recognition; perception; architectural style.*

Recognizing architecture

We take it for granted that we are able to learn and recognize particular styles, as well as distinguish between them. Architecture students are expected to comprehend style by being exposed to a number of relevant buildings. Students may experience such buildings only vicariously, through images and comments in lectures or books, as well in images they have to produce themselves. The relationships between style and image, representation and recognition are the focal points of the present paper, in particular the combination of two common claims concerning classical architecture: (a) most people can recognize a classical building directly and almost intuitively, and (b) drawings play an important role in the propagation of classical architecture. The first claim appears to hold within a specific cultural framework, even though many perceivers may experience difficulty in distinguishing between different styles and periods. The second claim appears to be even stronger: drawings still remain a primary carrier of architectural information, despite the wide availability of photographic and video imagery. Palladio's influence, for example, owes to the rich illustrations in his books. The economical text of the books deals mostly with practical building matters. The drawings, on the other hand, provide an overview of the form of his designs at an abstraction level suited to understanding their spatial articulation and explaining their underlying principles.

Recognizing classical architecture

Probably the most succinct and straightforward definition of a classical building is a building whose decorative elements are classical, i.e. derive from ancient Greece and Rome (Summerson, 1980). This apparently superficial definition makes a usable distinction between classical architecture and classical references. It also links architectural with lay perception. General cognitive mechanisms that determine object recognition make prominent elements equally well perceivable to all. As a result, such elements can be used to define classical architecture. It is not accidental that most treatises on the classical canon introduce the classical orders on the basis of free-standing columns and their superstructure in a temple colonnade (Summerson, 1980).

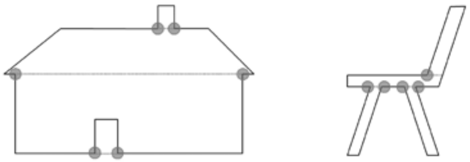

Figure 1
Transversality and colinearity: segmentation of man-made forms.

When we encounter a visual scene its initial recognition and general categorization relies on a rather unstructured collection of features and parts. The initial categorization of a scene as classical may require little in terms of element recognition. We are capable of immediately recognizing architecture as classical even in ruins or while heavily obstructed. Even more impressive is the immediate and unambiguous recognition of objects and parts. Doric, Ionic and Corinthian columns are complex structures but nevertheless directly recognizable as discrete parts of a colonnade. The underlying principle appears to be *transversality*, which suggests that we recognize parts in an object by linking adjacent points of deep concavity (Hoffman and Richards, 1985). In man-made objects it is advisable to add colinearity to transversality (Kim et al., 1987), probably because man-made structures tend to involve straight lines (e.g. due to manufacturing) and components that penetrate or underlie each other, resulting into a continuity of partially hidden lines (Figure 1).

The combination of transversality and colinearity allows us to distinguish not only between columns and their superstructure or base in a colonnade but also between the various components of a column (Figure 2). The fact that these components are eponymous appears to verify that architectural understanding of a classical element is based on such perceptual mechanisms. Even if the perceiver is not knowledgeable about classical architecture, these components remain unambiguous forms. This is because they belong to a small repertory of geometric primitives common to all forms we can perceive. Biederman calls these primitives *geons* and proposes that they are only twenty four in number (Biederman, 1987). Geons relate to each other in a limited number of relationships to form a vast repertory of configurations which are recognizable and describable even if unfamiliar or nonsensical.

Some configurations are easier to describe and remember than others. An explanation for this is found in SIT, the Structural Information Theory (Leeuwenberg, 1967). According to SIT a pattern is described in terms of an alphabet of atomic primitives. This description (the *primitive code*) carries an amount of structural information (I) that is equal to the number of elements it contains. The structural information of the primitive code can be minimized by progressively transforming the primitive code by e.g. *iteration*, which compresses pattern (1) into (2) and *reversal*, denoted by r […] (3). Reversal allows the description of symmetrical patterns (Σ), as in (4). *Distribution* expresses the nested repetition of a sub-

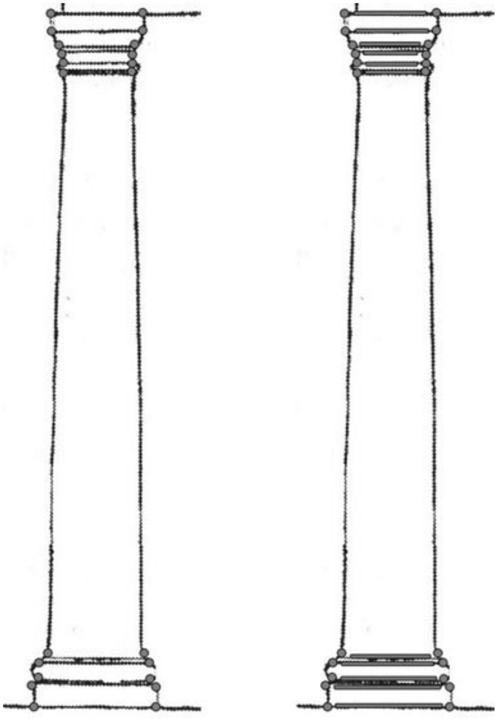

Figure 2
Segmentation of a Tuscan column.

pattern (5).

$a\ b\ a\ b\ a\ b\ a\ b\ a\ b\ a\ b$ (I = 12) (1)
$6 * [(a\ b)]$ (I = 3) (2)
$a\ b\ c = \mathrm{r}\ [c\ b\ a]$ (I = 3) (3)
$a\ b\ c\ c\ b\ a = a\ b\ c\ \mathrm{r}\ [a\ b\ c] = \Sigma\ [a\ b\ c]$ (I = 4) (4)
$a\ b\ a\ c = \langle(a)\rangle\ \langle(b)\ (c)\rangle$ (I = 3) (5)

The coding process returns the *end code*. The structural information (I) of a pattern is that of its end code. Patterns with compact end codes are easier to describe, remember and recognize because they make efficient use of our perceptual information processing capacities. Classical columns do not have such compact end codes. The complexity that results from variation in the form and in the articulation of their parts permits little compression of the primitive code. However, if we abstract a column to a single element, as in Figure 3, the trabeated post-and-lintel structure of a Tuscan colonnade is abstracted into a pattern of just two elements:

$v\ h\ v\ h\ v\ h\ v\ h\ v$ (I = 9) (6)

This code can be compressed through symmetry (7) or distribution (8). The equivalence of both descriptions in terms of structural information illustrates the frequent possibility of equally good alternative descriptions for the same pattern. This signifies a certain complexity in the pattern, e.g. the combination of several principles of spatial organization, and the corresponding complexity of our visual recognition and analysis, including the ability to recognize unintended regularities.

$\Sigma\ [v\ h\ (v)]$ (I = 4) (7)
$v\ \langle(h)\rangle\ \langle 4 * (v)\rangle$ (I = 4) (8)

The abstraction of a column into a single primitive can be approached from two distinct but complementary viewpoints. The first one is abstraction by means of spatial resolution. This allows deferment of recognition and description of details: we can start describing a scene as a classical colonnade and later elaborate by identifying the order as Corinthian. The second approach to abstraction puts more emphasis on the role of memory and learning: patterns with which we are confronted regularly become familiar chunks that can be abstracted into single, compound entities.

The identification of stylistic elements such as axial and translational symmetry is possible not only in the global structure of a colonnade but also in the articulation of an individual element. This presupposes an analytical view of the classical canon as a system of elements, relationships and coordinat-

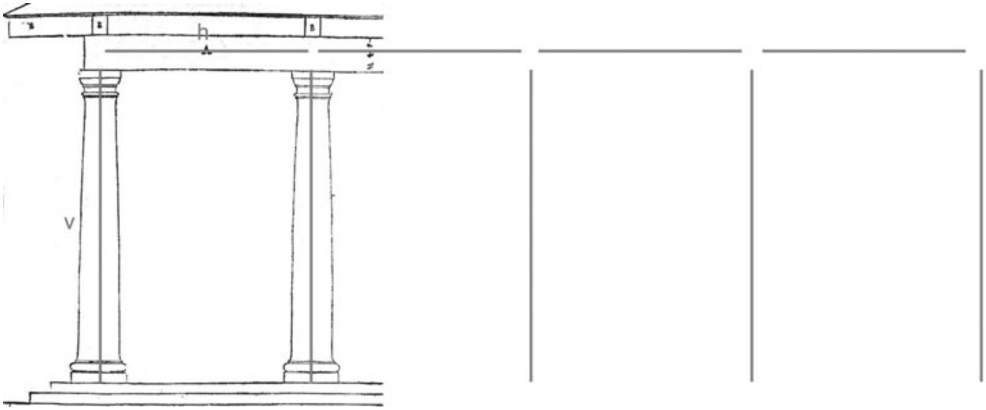

Figure 3
Colonnade abstraction.

ing devices (Tzonis and Lefaivre, 1986). This system consists of three levels: *genera, taxis* and *symmetry*. *Genera* denotes the orders, the sets of architectural elements belonging to Classicism. *Taxis* is responsible for the overall organization of a classical building and contains two sublevels: the *grid* and *tripartition*. A rectangular grid and a simple tripartition schema produce a 3 x 3 pattern which can be elaborated into e.g. the 5 x 3 grid of Palladian villas (Wittkower, 1988). *Symmetry* is the collection of relationships that constrain the positioning of a genus inside the divisions determined through taxis.

Tripartition becomes visible in the articulation of an order either by lowering resolution to achieve abstraction or by grouping geons. Either choice returns initially the obvious subdivision into the *entablature*, the horizontal part above the column, the *column* as a vertical, generally cylindrical part, and the optional *stylobate* or *pedestal* on which the column rests. Each of these parts comprises a homogeneous collection of geons that share certain common characteristics, such as orientation. The primary parts are also (recursively) tripartite. The column, for example, is subdivided further into the *capital*, the *shaft* and the *base*

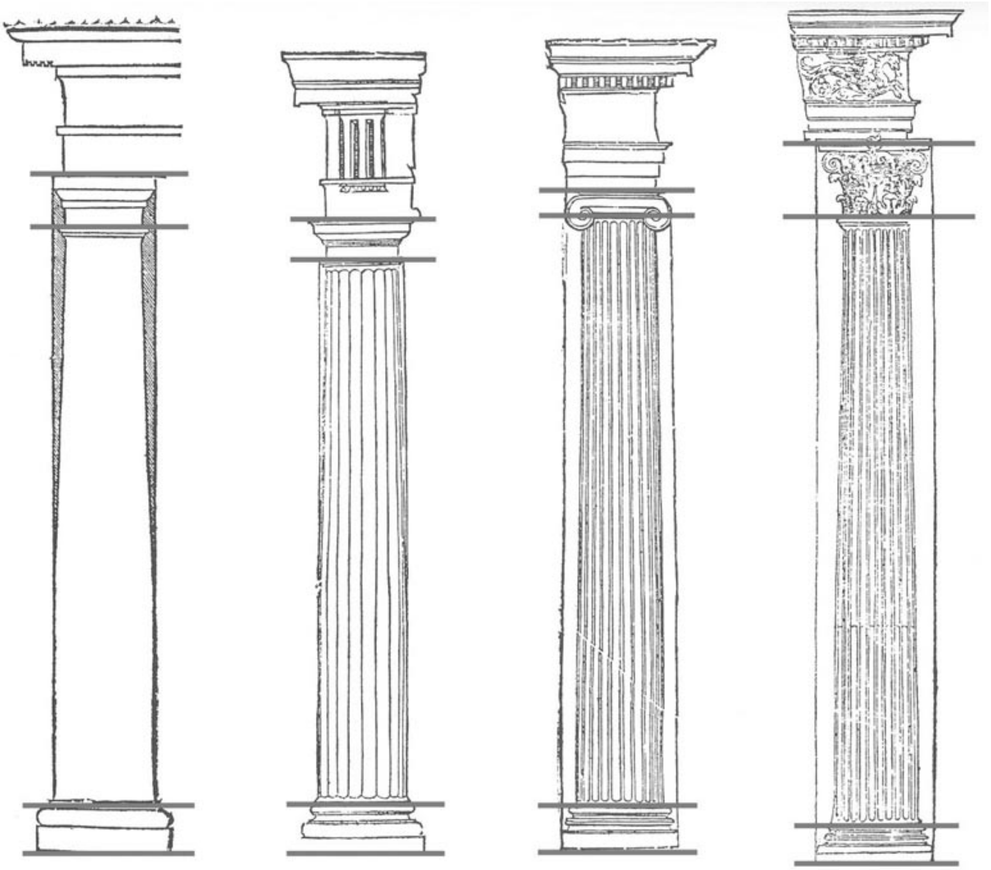

Figure 4
Tripartition in columns.

(except Doric columns – Figure 4).

Symmetry is a more complex matter, not only because classical theorists present a wide spectrum of possibilities ranging from strict formulaic expressions to vague statements about harmonious relationships between parts, but also because of a recent wider discussion about the role of proportion and symmetry in anthropology, psychology and other sciences. This discussion has been converging towards formulaic relationships that underlie our aesthetic preferences. Anticipating further research into the subject, we may observe that perceivers of classical buildings expect individual classical elements to have an axial symmetry similar to that of mammals.

Architectural drawings of classical buildings

Drawings play an important role in the propagation of classical architecture. We have mentioned the significance of Palladio's illustrations, which follows the tradition of illustrated manuals initiated by Serlio. This tradition involves the development of drawing styles specifically for publication. The resulting abstraction levels also relate to design sketching and architects' interest in partial or elliptical descriptions that stress particular subjects. Palladio's woodcuts put emphasis on the total composition and accentuate fundamental similarities between different designs. Readers are not presented with a prescriptive system (as in analytical or computational recreations) but with examples of an implicit framework (Ackerman, 1977).

Reading the floor plans and elevations in the books of Serlio or Palladio assumes some familiarity with the represented elements and structures. Part of this is provided by the same books but the problem is essentially resolved by elevating the classical elements to the level of integral primitives. Any column is a discrete, fixed structure that does not require particular attention beyond conformity to a canon. This makes the drawings more symbolic than representational in structure and adds to their analytical intentions. The ability to abstract classical elements in a drawing makes explicit their arrangement on a 3 x 3 grid or other schema used to achieve a harmony of parts. It also facilitates the presentation of Classicism as a coherent formal system to be superimposed onto a general (neutral) framework of designing and building.

Elevations, perspectives and axonometrics represent the appearance of classical buildings in a stylized manner. The main differences with photographs or paintings are: (1) most drawings make measurable the geometric properties of the buildings, and (2) architectural drawings make explicit the edges of surfaces. Edge detection is considered to be an essential early step in vision. The significance of edges lies in that they indicate change, e.g. the boundary of an object or a characteristic marking on its surface, and thus they provides information on the form or the character of the object.

Perception and recognition of classical elements and in edge-based building representations is based on the propagation of expectations from critical features (vertices and edge junctions) in order to form surfaces and volumes (Waltz, 1975; Huffman, 1971; Guzmán, 1966; Clowes, 1971). This is based on two fundamental collections. The first is a comprehensive typology of critical features. In a rectilinear

Figure 5
Edge junction types in a drawings of rectilinear three-dimensional scene: (left to right) L-type, fork, arrow and T-junction.

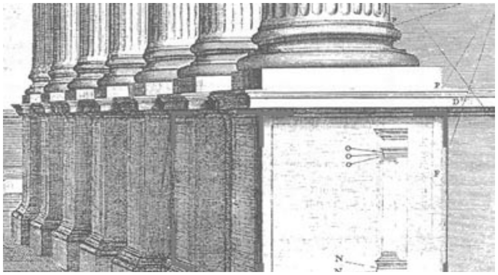

Figure 6
Recognition of surfaces and volumes in three-dimensional scenes.

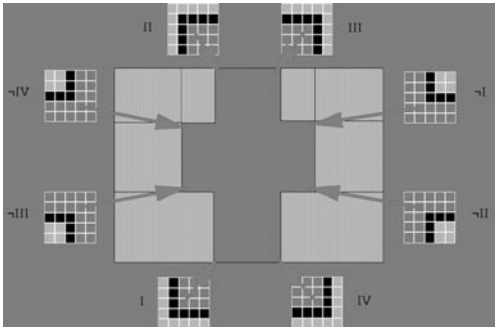

Figure 7
Corner types in a rectangular classical floor plan.

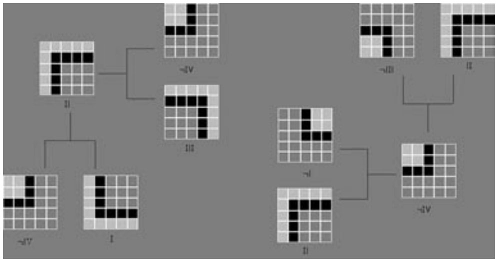

Figure 8
Corner connectivity.

three-dimensional environment there are four basic edge junctions (including occlusion – Figure 5). The second collection consists of expectations concerning the connectivity of each feature. The number of edge junctions connected to each of the edge junction types in Figure 5 is equal to the number of edges in the junction. The direction is also known (the direction of the edges). The type of connected edge junctions are inferred from the possibility of a particular combination. By propagating such expectations from all junctions we can identify the closed outlines of each surface and the volumes bounded by these surfaces in a parallel manner. Of particular importance is that in this way we are able to recognize the structure of the scene regardless of perturbations or incompleteness in the edges.

In floor plans of classical buildings building elements are frequently so schematic and abstract that they convey few of the details of their form: they lose most of the characteristics that make them significant as classical elements. Their main function becomes that of boundaries of spaces. Floor plans can be simplified further into diagrammatic layouts through skeletonization of the building elements. An obvious choice for space recognition in a skeleton is edge-following: starting from an arbitrary corner of the skeletonized floor plan we move to a connected corner in a clockwise or counter-clockwise fashion in order to identify the closed contour of a space. Due to its sequential character and its sensitivity to local noise edge-following compares unfavourably to the parallel feature-based recognition of three-dimensional scenes. A transfer of the latter to floor plan is based on a comprehensive typology of space corners (Figure 7) and connectivity expectations (Figure 8) to recognize individual spaces (Koutamanis, 1990; Koutamanis, 1995). This approach also relates to human perception of subjective or illusory contours: forms recognized on the basis of their salient features rather than their outlines (Kanizsa, 1979).

The recognition of spaces in a floor plan paves the way for the identification of grouping and the analysis of aspects relating to taxis. Space grouping can be based on the principles of SIT so as to return a bottom-up clustering that reflects specific stylistic preferences. An alternative that also links architectural perception with basic organizational phenomena in perception is to analyse the invariance of a floor plan over the group of Euclidean similarity transformations (Palmer, 1983).

Conclusion

The recognition of elements and aspects of a style such as Classicism in drawings involves a complex network of constraints. A large part of these rely on the selective application of general perceptual principles in order to accentuate issues relevant to the style. Classicism appears to favour scene interpretations that aim at informational clarity and economy, resulting into compact descriptions. These facilitate abstraction and identification of crucial relationships between the parts of a scene.

General perceptual and cognitive capacities need to be complemented with elementary knowledge of drawing conventions. Knowing what the projection is and understanding the semantic differences between different lines types is sufficient for general identification. One level higher, identification of basic features and parts is still primarily based on general cognitive principles. Recognition of building elements and spaces as geons or contours requires no special skills or architectural knowledge. Identifying an element as classical is a mixed affair. It refers to general principles such as symmetry and tripartition, which stress the well-formedness of an object even to perceivers unaware of the classical constraints, but it does not *explain* well-formedness. Any explanation presupposes acquaintance with the classical canon.

The increase of complexity and uncertainty as the perceiver moves from global aspects to details is arguably related to our variable knowledge and understanding of classical architecture. Identification of the primary, more abstract features of classical architecture requires little domain knowledge. Exposure to classical architecture results into the labelling of an already known class of building features as classical. Such exposure may involve both structured learning and arbitrary memorization (primarily based on personal experience). Knowing how to project a grid or tripartition scheme to a building image is as effective for the recognition of a classical building as identification of an abundance of local classical features in a regular, symmetrical structure. Understanding of the classical canon adds to the efficiency and reliability of recognition but even more to the appreciation of classical architecture.

The influences between general cognitive mechanisms and domain knowledge are complex and variable. The classical canon appears to make extensive use of such mechanisms but these mechanisms are not always subordinate to domain knowledge. For example, it is possible to subdivide many floor plans by applying transversality and colinearity to their total outline. The resulting wings are generally convincing as parts of the building with some degree of fuzziness due to differences between the overall building form and its internal spatial structure. The opposite is also possible: in SIT it is assumed that the canonical object relation (the one that does not have to appear in the primitive code) is horizontal. This is arguably due to the horizontal direction of writing in many cultures. In buildings the canonical direction is normally vertical, presumably due to the importance of gravity.

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