A Possible Palladian Villa

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Approaching Virtual Reality.

Ever since Wittkower published *Architectural Principles in the Age of Humanism* in 1949, in which he showed that Palladio’s villa plans are based on a tartan grid, it seemed that Palladio’s design principles had been encapsulated. When subsequently, in 1978, Mitchell and Stiny enunciated all the topological possibilities for Palladian villa plans, it appeared that the case was closed. Freedman and Hersey have since shown that it is precisely in the application of specific building dimensions and proportions that additional design rules come into play, however.

The present study builds on the work of Freedman and Hersey. It uses and extends their method which involves incorporation of the known design principles for Palladian villas, as given implicitly in Palladio’s *Four Books of Architecture* and in his built works, into a computer program capable of generating schematic plans and elevations based on those principles and visually comparing the generated plans and elevations with the known works of Palladio. In cases of disagreement, the reasons for the disagreement help formulate further design rules.

The Hersey and Freedman program is used as a starting point in the present study to generate a large number of villa plans which in turn lead to the discovery of additional Palladian design rules by the above process of visual comparison. Most of the generated plans do not satisfy the additional rules and must be eliminated as not being Palladian.

Of the remaining plans one is chosen for manual elaboration into a full three-dimensional computer model entailing further levels of detail and, consequently, further design rules and possible alternatives. These further design rules and alternatives are again determined by drawing visual comparisons, in this case, between the three-dimensional model and Palladio’s designs. Whereas the initial design rules where extracted by visual comparisons at the very abstract level of reality of two-dimensional schematic designs, the final comparisons are made at what is a virtual reality in three-dimensional space. This virtual reality is perceivable as an image of reality in the same way that a photograph of an outdoor scene is except for a certain degree of abstraction imposed by limitations of computer technology.

While previous investigations of Palladian villas have focused on the central block of the villa, this study includes the side wings, or barchesse, and a modelling of the Renaissance gardens likely to have surrounded a Palladian villa in the 16th century. Rules for the design of the barchesse are extracted from the designs in the *Four Books of Architecture* and are applied in the manual creation of a full three-dimensional computer model of the barchesse. The layout of the gardens is deduced from an understanding of the gardens which surrounded Renaissance villas in general and from what is known about a particular Venetian villa which preceded Palladio’s villas. The gardens too are then modelled in three-dimensions including topiary and trees.

In effect, this study postulates that it is only possible to fully understand an architect’s design principles when, after incorporating what one perceives to be these design principles in a design, a building results which visually looks like a work of the architect being studied. Hence the outcome of this study is a possible Palladian villa but the objective is not the villa but what can be learned about Palladio’s design intentions for villas along the way.
Figure 1: Villa Giustinian showing Cortico, Brolo Piccolo and Brolo Grande
The genius of Palladio lay, as James Ackerman expressed it, in finding "freedom and inspiration to build exciting structures" in "the knowledge of the boundaries in which he had to maneuver - the tradition of the distant and immediate past, the specific demands of his clients, the choice of material and of the site" (Ackerman, 1983). In view of the obvious formal clarity of Palladio's designs for villas, it is tempting to consider these designs purely as a manifestation of design rules. Although this study is concerned with Palladio's formal design principles, one must heed Ackerman and proceed in the recognition that one cannot examine the formal boundaries without simultaneously being aware of the other boundaries to which Palladio's villa designs were subjected. Hence this investigation must necessarily commence with an overview of Palladian villas and their context and continue, at the appropriate place, with related overviews concerning the side wings or barchesse and the gardens. Without this understanding it is not possible to appreciate the factors which were the source and the limitation of Palladio's formal choices.

Palladio's Villas.

At the outset it should be noted that the term villa was used in the Renaissance to denote an entire estate, the land and all the buildings. Thus when Palladio spoke of the villa as we understand it now he would have had to say casa di villa. I shall also use "main villa block" or the "main block" interchangeably with casa di villa. The casa di villa of Palladio's villas was not large, in terms of the number of rooms, when compared to English country houses in the Palladian style during the next century (Holberton, 1990). Their imposing grandeur was derived, in some cases, from the incorporation of utilitarian structures, the barchesse, into the side wings of the casa di villa.

Palladio's villas are situated in the eastern part of the Veneto (which is a present day area referring to Venice's mainland territories in the Renaissance and includes the cities of Vicenza and Padua). All of the villas were within a day's travel from Venice in the 16th century. They were built in the period between 1530 and 1570 after peace and stability had come to the region following the wars of Cambray which ended in 1517. As a result of Venice's changing circumstances during this period, such as increased competition in maritime trade from Atlantic powers, Turkish advances, Venice's growing population in need of a secure food supply and a developing taste for the charms of country life, an interest developed in investing in land on the Terraferma (Ackerman, 1983). Venetian patricians with mainland holdings from the previous century, mainland aristocrats with feudal titles dating from the Middle Ages and Venetian patricians who were buying land in the Veneto, were building villas from which to manage their farming investments. Besides the management function, these villas also had to accommodate the life of luxury that the owners of the villas were used to and to indicate their exalted position in society. Palladio recommended that these farming villas be situated near rivers and canals to facilitate shipping of farm products and to provide a source of water for irrigation and gardens. The extended wars of Cambray had caused a break in a generation of architects resulting in a desire for change and a reorientation to Roman ideas. Palladio appeared at just the right moment and succeeded in blending the new Roman aspirations with local traditions rooted both in the working farm and the fortified villa (Ackerman, 1983).

The layout of a Palladian villa may conveniently be introduced by considering the layout of one of these fortified villas, namely the Villa Giustinian at Roncade dating from 1510. As can be seen in Figure 1, the main villa block is flanked on either side by long barchesse which also double as part of the fortified walls enclosing the villa compound. After entering the compound through a gate with towers one finds oneself in a large entry courtyard, the cortico. The main villa block is linked on either side by connecting walls to the barchesse. These walls separate the cortico from a garden at the side of and extending behind the main villa block to the fortified walls. There is a gate in the fortified walls behind the main villa block which leads to an area enclosed, it seems, by hedges and a small canal. This area, known as the brolo piccolo, appears to be an orchard. Beyond the brolo piccolo is a wood, the brolo grando (Holberton, 1990a).
Figure 2: Wightman’s Eleven Schematic Plans


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In villas of the Veneto which preceded Palladio’s villas, like the villa Giustinian, it was customary to have a large room in the center of the ground floor for receiving the public. This was known as the entrata. Directly over the entrata on the first floor above, on the piano nobile, was an equally large room known as the sala. To use Palladio’s words, this room was “for entertainment, for banquets, for staging and recitation of comedies, for weddings and similar recreations” (Palladio/Ware, 1735). Symmetrically disposed on either side of the sala and opening off the sala were two or more smaller rooms each of which was known as a stanza. These rooms might be called gentlemen’s sitting rooms but otherwise served no specific purpose. They could serve as the husband and wife’s sitting rooms, since they usually had their rooms on opposite sides of the house or they could accommodate guests. Off the stanza opened still smaller rooms, the bedrooms, each of which was known as a camerino. The stanza could also be used as study rooms or libraries.

Although the layouts of rooms in Palladio’s villas took their cues from predecessors like the villa Giustinian, they do not have an entrata on a separate floor in most cases. The exceptions are two storey villas such as the Villa Cornaro at Piombino Dese and the Villa Pisani at Montagnana. Instead, the arrangement is as follows: The main focus of the layout is on the piano nobile, in particular, on the sala which serves the functions just noted. The sala is on the central axis of the villa about which the floor plans are biaxially symmetric. One or both of the front and back entries to the sala may be served by a portico of either the prospice type, that is, projecting out from the facade, or the in antis type, that is, recessed into the facade with the columns in line and slightly projecting from the facade. This portico, for which the Villa Giustinian set an authoritative precedent, supplanted the entrata of the villas before Palladio. If no portico was provided on one end of the sala, Palladio sometimes provided a vestibule, although at other times he provided the vestibule in addition to the portico. As in preceding villas, a number of stanze opened off the sala. In Palladio’s case these occurred in pairs on opposite sides of the axis of symmetry and these stanze in turn opened onto still smaller rooms, the camerino, also paired, which in turn opened onto even smaller rooms known as camerini. The latter could serve as the owner’s studiolo or simply as storage space. A group of stanze, camerine, and camerini thus formed two sets of apartments on either side of the villa for husband and wife or sometimes two brothers. The piano nobile of Palladio’s villas provides a clear transition of spaces from public ones, such as the entrata/porch, the vestibule and the sala to the semi-private stanze and finally to the private camerine and camerini. Palladio indicates the intended sequence on his plans by drawing the door frames such that it is clear on which side the doors must hang and into which rooms they must open. Moreover, Palladio orchestrates the sequence by carefully relating the proportions of adjacent rooms as will be discussed again below (Holberton, 1990c). Finally, in addition to the constraints already imposed by function, symmetry and the public to private sequence, Palladio also noted that summer rooms should be large and face to the north while winter rooms should face south and be small so that they can be more easily heated (Palladio/Ware, 1735a).

Servants quarters were in the attic or mezzanine storey above which, due to its low ceiling height (less than 2.5 metres), was not considered fit for gentlemen. In fact servants spaces were used interchangeably for the storage of grain (Holberton, 1990c).

The piano nobile was raised up from the ground by having a basement beneath it (the Villa Giustinian was one of the first villas of the Veneto to have a basement, thereby once again setting a precedent which Palladio was to exploit in all of his villas). As Palladio stated, the "upper apartments are wholesome to live in, the floor being at a distance from the dams of the ground; besides as it rises, it is more agreeable to be looked at and to look out of." (Palladio/Ware, 1735a)

Within the basement, Palladio located the more disagreeable parts of the villa such as kitchens, wood stores, wine cellars, pantries, servants day rooms, washing places and ovens.
Figure 3: Plans and Elevations Generated by the Freedman and Hersey Program
Figure 4: Plans and Elevations Generated by the Freedman and Hersey Program
Figure 5: The Selected Plan and Elevation Generated by the Freedman and Hersey Program and the Manually Corrected Version on the Right.
Palladian Design Rules.

Wittkower.

In Architectural Principles in the Age of Humanism (Wittkower, 1988), Rudolf Wittkower wrote of Palladio's villas as follows: "But the plans of the many country houses, which he built as the fashionable architect of Vicenza from the 1540's onwards, are all different orchestrations of the same theme..." derived from a single geometric formula. The basis of Wittkower's conclusion is an illustration in his book which is entitled "Schematised plans of eleven of Palladio's villas". It is redrawn here as Figure 2. What Wittkower saw as a "single geometric formula" was that to him each of the eleven villas have their walls so positioned that they fall for all or part of their length along an underlying tartan grid consisting of five intervals horizontally and three intervals vertically. The five by three grid is shown in the lower right of the figure. A careful scrutiny of Wittkower's schematic plan of the Villa Pisani at Bagnolo reveals, however, that a grid having seven intervals horizontally and four vertically is more appropriate than the five by three grid (notwithstanding some liberties taken by Wittkower in his schematic in the area of the stairs). Similarly the schematic of the Villa Rotunda, while drawn correctly, requires a five by five grid. While there are other villas which have Wittkower's five by three grid such as the Villa Saraceno, or the Villa Angarano, there are others which require grids of five by four, three by five and five by six.

Wittkower also took the position that the dimensions which Palladio shows very conspicuously on his plans in The Four Books of Architecture were intended to convey Palladio's intentions with regard to the proportions of the rooms and the relationships of the proportions between rooms. The fact that the dimensions of the rooms as actually built differ from the dimensions in The Four Books only reinforces, in Wittkower's view, the conclusion that Palladio's dimensions in The Four Books, which are almost always integers (of Vicentine feet) are ideal dimensions conveying Palladio's proportional intentions. Wittkower felt that the difference between the ideal and the executed dimensions was not sufficient to be perceivable to the eye. That Palladio was concerned about the proportions of rooms is corroborated by what he has written in The Four Books where he provides the ideal room proportions in plan: 1:1, 1:1.2, 1:1.1/3, 1:1.1/2, 1:1.2/3, and 1:2 (Palladio/Ware,1725b). Palladio also provides several rules for the relationship between the plan dimensions and the height of rooms for flat or vaulted ceilings, leaving some room for judgement (in chapter XXIII of book two). He was, furthermore, careful to provide a variation in room sizes as one proceeded from one room to another in the sequence from public to private and he took care that this variation was neither too sudden or too small to be perceived as a variation. Often, Palladio achieved this variation by ensuring that the short side of a large room became the long side of an adjacent smaller room (unless one of the rooms was square) (Holberton,1990d).

For the exterior of the villas, Wittkower again saw Palladio as using one underlying theme and many variations on that theme. The theme, as he saw it, consisted of a cubic mass for the main villa block with "essentially perceivable ratios between length, depth and height" (Wittkower,1888) and a temple front attached either in front in the prostyle manner, as at the Villa Malcontenta, or in aniz, as at the Villa Emo or integrated into the entire facade as at the Villa Barbaro. In seeing the exteriors of Palladio's villas "all generated from the basic pattern", Wittkower did not appreciate, however, the range of expression available to Palladio within his chosen vocabulary for the elevations of his villas. This may be concluded from the fact that he gives no reasons as to why Palladio might have preferred one alternative over another within his "basic pattern". While it is true that Palladio's facades may be characterised along Wittkower's lines, this would not make the facades exclusively Palladian. One would not be able to distinguish Palladio's villas from, say, Vincenzo Scamozzi's Villa Pisani (La Rocca), his Villa Molin or even Lord Burlington's Chiswick House.
Figure 6: Modeled Casa di Villa, First Scheme, Showing View of Main Entrance

Figure 7: Modeled Casa di Villa and Barchese, First Scheme, Rear View

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Stiny and Mitchell.

Stiny and Mitchell (Stiny and Mitchell, 1978, 1978a; Mitchell, 1990) were the first to characterize the plans of Palladio’s villas as resulting from the application of a set of rules, specifically shape grammars, which are potentially programmable into computer algorithms. They extended Wittkower’s characterization of Palladio’s villa plans in several ways: They generalized the underlying grid so that it is not restricted to one consisting of a 5x3 grid of cells but a grid of variable size, (2m+1)x(2n+1) with m > 0 and n > 0. They provide an explicit set of rules for concatenating cells in the grid which results in numerous possible room layouts including layouts with T, I, and + shaped central rooms or salae, whereas Wittkower only implies the existence of such rules by allowing the reader to compare the plans with the underlying grid. Mitchell and Stiny provide rules for shifting walls off the grid by small, unspecified amounts so that the resulting rooms may have harmonious proportions in accordance with Palladio’s ideal dimensions, but they do not consider proportion (Stiny and Mitchell, 1978a). They also provide a lexical selection of plan alternatives for porticos and exterior wall inflections and selections of alternatives for the placement of columns within the porticoes. Finally, they offer a rule for the placement of windows and doors along axes which correspond to the center lines of the cells in the underlying grid.

With Mitchell and Stiny’s rules it is possible to enumerate all the topological possibilities for the plan of Palladian villas. Mitchell and Stiny have done so manually for a 3x3 grid and for Wittkower’s 5x3 grid. They deemed it “a simple exercise” to parameterize the rules with Palladio’s specific proportions and with actual dimensions in order to generate specific Palladian plans (Stiny and Mitchell, 1978a). The subject seemed exhausted. All that remained to be done was to generate the facades. The problem with Mitchell and Stiny’s rules is not that they are incorrect but that they are incomplete. This is not evident, however, unless specific proportions and dimensions are inserted into the plans generated by their rules, and it is then observed that only some of the resulting plans are Palladian. One can see this even at the topological level in the alternatives enumerated by Stiny and Mitchell for the 3x3 and the 5x3 grids because they include very un-Palladian plans with rooms spanning the entire plan (even Mitchell and Stiny expressed some reservations about including these schemes) (Stiny and Mitchell, 1978a). It would be a grave understimation of Palladio’s genius if his plans could be characterized completely by Mitchell and Stiny’s rules (Remember Ackerman). As will be shown presently, further rules come into play to distinguish Palladian from non-Palladian plans.

Freedman and Hersey.

Freedman and Hersey (Freedman and Hersey, 1993) go beyond Mitchell and Stiny in that they provide an approach not only for the generation of Palladian plans but also for the generation of elevations and incorporate both in a computer program (Mitchell and Stiny’s work was manual as was the enumeration of plans). The computer program, which runs on any Macintosh, mediates the conflicting demands of the plan and elevation. The program goes beyond Wittkower’s characterization of the main villa block as a cubic mass with attached portico by treating the main villa block as superimposed blocks of different types. The blocks include, for example, base blocks of different configurations, blocks for the first and second floors, entablature blocks, attic blocks and roof blocks. The blocks for the different floors offer choices for the types of entry and attached porticoes but the computer program works out the column spacing for the porticos on the basis of Palladio’s recommendations for the different orders. The program also coordinates the placement of windows with the plan and the column spacing of the porticos.

At first glance, Freedman and Hersey’s plan generator appears, except for the fact that it is computerized, a duplication of Mitchell and Stiny’s effort by an alternate formulation of the rules (indeed Hersey and Freedman’s work began without knowledge of Mitchell and Stiny’s papers). It transpired, however, that precisely because the Freedman and Hersey program uses specific dimensions and proportions that results of early versions of the program immediately pointed to the need for additional rules which would eliminate plans acceptable under the
Figure 8: Modeled Casa di Villa, Second Scheme, View of Main Entrance.

Figure 9: Modeled Casa di Villa and Barchese, Second Scheme, Rear View.
Mitchell and Stiny rules. The additional rules incorporate the following:

1. Room proportions in a continuum over Palladio’s recommended range of proportions (1:1, 1:2, 4:3, 3:2, 6:3, 2:1).
2. Rooms on the axis of symmetry tend to be larger than adjacent rooms.
3. Rooms should have a range of sizes based on probabilities according to which a given size is subdivided.
4. No room as long or as wide as the plan.
5. No room dimension less than 7 Vicentine feet.
6. Total number of rooms equal to or less than 20.
7. Total number of interior rooms without windows is equal to or less than 4.
8. The number of rooms in a row horizontally is less than 7.
9. The ratio of the smallest to the largest room area is 9.

A current version of the program which the author has tested incorporates rules 1 to 5. The program also includes rules which, in effect, determine the type of underlying grid (eg.5x5) and the probability of its occurrence and rules which, in effect, determine the proportional spacing of the grids and the probability of their occurrence.

Up to the point where specific dimensions and proportions are inserted, Freedman and Hersey’s program involves, in essence, the same procedure. Whereas Mitchell and Stiny proceed by removing parts of walls from an initial grid of walls, occasionally shifting off the grid to allow the creation of a room with more nearly Palladian proportions than would otherwise be the case, Freedman and Hersey proceed by subdividing a rectangle corresponding to the outline of the plan horizontally and vertically where the number of times the plan is split horizontally and vertically and the proportional spacing of the grids is based on the frequency of occurrence in Palladio’s built works and on the unbuilt works in *The Four Books*. The program continues to subdivide the initial split using probabilities, again based on Palladio’s built and unbuilt works, to decide when to split a space using a probability to split based on the size of the room, thus ensuring a range of sizes in rooms in order to steer the resulting room shapes towards Palladio’s ideal proportions. When deciding to split rooms into smaller rooms the program tends, for the most part, to align walls but will occasionally allow walls to be remain shifted off the grid as allowed by the Mitchell and Stiny rules.

A major difference between the two approaches then, is that the Hersey and Freedman program uses probabilities in the recognition that Palladio did not employ his various design rules with equal frequency. The disadvantage of this approach is that it is difficult to systematically enumerate all the possibilities. By running a large number of cases one can obtain, however, an understanding of the types of designs Palladio would have preferred although any particular generated design could represent one of Palladio’s least probable choices.

There are also some differences between the two approaches in the interpretation of those Palladian design rules which both have in common. For instance, Mitchell and Stiny’s rules, do not allow vertical shifts of horizontal walls for rooms which are off the axis of symmetry and they do not acknowledge that behind porticoes it is the column spacing which determines window locations rather than the axes of the rooms. Neither program incorporates all the nuances of door/window placement. To cite one example, Palladio does not always place the door/window axes along the centerlines of rooms when the rooms are on the perimeter of the plan as in the Villa Malcontenta. Here the windows are shifted towards the side of the building. A disadvantage of Hersey and Freedman’s program is that it cannot generate T, I or +-shaped rooms. These have to be created by manual erasures. While Hersey and Freedman incorporate rules for the spacing of columns in their porticoes based on Palladio’s descriptions of the orders in *The Four Books*, they have not accounted for the fact that the column spacing is usually not equal in order to allow for a wider spacing of those columns which align with either side of the entrance. Mitchell and Stiny indicate the unequal spacing in their lexical selection of alternative porticoes and entrances but do not provide any proportional rules for column spacing.
Figure 10: Modeled Casa di Villa and Barchese, First Scheme, View of Cortivo.

Figure 11: Modeled Casa di Villa and Barchese, Second Scheme, View of Cortivo
Generating the Basic Villa Plan.

The starting point on the route towards a possible Palladian villa was to use the current version of the Herzey and Freedman program to generate a large number of plans and corresponding elevations. Given that the current version of the program incorporates only the above rules 1 to 5, generated plans which did not satisfy rules 6 to 9 were manually rejected. After rejecting numerous plans (up to 100 for each selected plan), fifty six were selected. Forty of these are reproduced in Figures 3 and 4. Accompanying the plans in Figures 3 and 4 are elevations which were selected using options which the program deemed suitable for the plans. When these plans are classified on the basis of the topological arrangement of the rooms as enumerated by Mitchell and Stiny, there are twenty six unique layouts. There are schemes with the following underlying grids: 3x2, 3x3, 3x4, 5x3, 5x4, 5x5, 7x3, and 7x4.

The next step was to select from the enumerated plans the ones which looked most Palladian by visual comparison with Palladian designs. In making this final selection, further rules presented themselves with which to distinguish Palladian from non-Palladian plans. These are:

1. The large central room, the sala, must be on the perimeter of the plan (for light) or one room removed from the perimeter, so that the adjacent room can serve as a portico in antis. This means that an exterior wall has to be removed manually if the sala has a room serving as a loggia adjacent to it.

2. The depth of the loggia formed behind a portico in antis should be less than the dimension of the sala along the axis of symmetry.

3. Two or more identical rooms in a row are not allowed (although Herzey and Freedman's program creates variety in a probabilistic sense, it does not avoid specific instances where there is no such variety).

4. Adjacent rooms should follow the principle noted by Wittkower where the short side of a large room becomes the long side of an adjacent small room.

5. The plan must have some camerini, the small rooms used for storage, studioli, and staircases (Villa Ragona and Villa Poiana are exceptions where Palladio does not show an enclosing room around the stairs).

6. There should not be too many rooms adjacent to the sala, ideally not more than four, where the short dimension of the sala is much greater than the long dimension of the adjacent rooms in order to prevent configurations with a ring of similarly sized rooms around the sala.

7. The portico should be wider than the narrowest part of the sala in the case of T-shaped and I-shaped sala.

Only a handful of the fifty six generated plans satisfy the additional seven rules. One of these is selected for further consideration. It is shown on the left in Figure 5 together with the elevation. Considering that on one side of the sala there is a room between it and the perimeter, this room becomes a loggia in fulfillment of rule 1. The change of this outer room to a loggia was done manually and is reflected on the right side of Figure 5. On the side opposite to the loggia this plan shows a vestibule at the entry to the sala. The portico evident on the computer-generated elevation on the left of Figure 5 was interpreted as a portico of the prostyle type so as to provide for the receiving of visitors. Again the plan was manually revised to show the projecting portico and is reflected in the plan on the right side of Figure 6.

While this was considered the most Palladian plan of the generated plans it does have some deficiencies. It has more than four small camerini, two of which are obviously for stairs to the attic story, although there are several possibilities as to which two are chosen. Also, this plan comes uncomfortably close to one having a ring of rooms around the sala. Its saving grace is the loggia and the adjacent stanza.
Figure 12 Palladio's Alternatives for Barchesse.

Elaborating the Villa.

The Casa di Villa.

For the next level of reality in the development of a possible Palladian villa, the schematic design on the right side of Figure 5 was manually elaborated into a full three-dimensional model using the GDS solid modeller. Included in the three-dimensional model are the barchesse and the Renaissance gardens. Consider first, however, the casa di villa, for which the three-dimensional model was created by scaling the laser plot of the schematic plan and elevation in Figure 5 on the basis that the walls are two (Vintenze) feet thick. Additional detail not evident in the schematic plan and elevation, such as column capitals, column bases and additional detail for pediments, entablatures and cornices, were then "designed" along supposed Palladian lines and incorporated into the model. Window frames were also added, although not all Palladian villas have them, even the villas, such as the Villa Emo, of Palladio’s wealthier clients. Finally the stairs needed to be worked out for the front and rear elevations along lines suggested in Figure 5 and side stairs, such as those at the Villa Badaro, added to provide access to the loggias leading to the barchesse.

Internally, floors and walls were added to demarcate rooms at the basement, piano nobile and attic floor levels in anticipation of creating section views.

Critique of the Casa di Villa.

The first attempt to model the casa di villa in three dimensions is shown in Figures 6 and 7. Although this building, at first glance, appears Palladian, the eye trained in Palladian details will subsequently perceive a number of features not seen in Palladio’s oeuvre, some definitely not and some likely not. Each of these features implies a Palladian design principle although not all of them are uniquely Palladian. Consider therefore some of these un-Palladian features.

Most obviously un-Palladian is the portico in Figure 6. It is too shallow with hardly enough room to stand beneath out of the sun and rain (this portico also does not agree with the layout for the portico on the right in Figure 5 which was drawn after seeing the model in Figure 6). Furthermore, the entablature of this portico does not align with the entablature bands around the main villa block at the attic level. The columns are also problematic because they are based directly on the columns in the schematic elevation in Figure 5. Whilst in the schematic elevation they are simplified as having a constant diameter and being equally spaced, classical columns always taper towards the top with some degree of entasis and, in Palladio’s case, are spaced unequally to allow more space between the columns in front of the entrance. Other details around the portico are also un-Palladian. The handrails of the side stairs, for example, lack depth, the balusters are too far apart and the rails lack end posts. Also, the ends of the main stairs should continue the balustrade which encircle the main block.

The rear elevation of the first model of the casa di villa is visible in Figure 7. The loggia is designed as a rectangular cutout in the rear facade which again does not appear in Palladio’s oeuvre and does not appear as something Palladio would have chosen to do. It strikes one as a contemporary move.

In consideration of these deficiencies a second model of the main villa block was created to remove the most obvious deficiencies concerning the depth of the portico and loggia at the rear. Figures 8 and 9 show the revised main villa block. The portico and stairs at the main entry have been extended and, at the rear, a shallow pediment has been added over the columns which have been moved outwards to support the pediment. Lack of time prevented further more detailed changes from being made. The front portico is now definitely Palladian with many precedents. The rear shallow pediment in front of the attic storey, while convincingly Palladian, has actually no precedent. Palladio’s shallow pediments are located at the cornice level. This need not be problematic except that the section in Figures 13 and 26 reveals that the columns may not be able to support both the pediment and the attic wall behind as they are not both on top of the columns.
Figure 12: Modeled North-South Section of the Casa di Villa.

Figure 14: Modeled Eye Level View of Orchard and Garden Pavilion.
Barchesse.

Barchesse are barn-like structures accessed for all or part of their length through an open loggia. They were, and sometimes still are, used for storing materials such as hay or grain (although the attic of the main villa block served this purpose also) and other produce which the owner received in kind as rent from his tenants. In the barchesse there was usually a place for wine making and wine storage and, at the ends of the building, accommodation for farm workers. Some of Palladio’s barchesse, such as those at the villas Emo and Barbaro, also have prominent dovecotes projecting up at the ends. A few of Palladio’s plans show stables in the barchesse although uses which produced odors were probably not considered desirable so close to the residence of the owner.

Palladio used the barchesse to partly define the cortile. In doing so he was continuing an earlier tradition evident in the cortile of the Villa Giustinian. Where Palladio goes beyond the earlier tradition is in the manner in which he incorporates the barchesse so that they become part of and an enhancement to the casa di villa, either directly by attaching to the main villa block, or indirectly, by being linked to the main villa block with a loggia. Moreover, he dimensions and proportions the barchesse so that they also become linked to the main villa block by repeating or extending harmonic, proportional sequences found there (Wittkower, 1988a). In the same vein one or more components of the barchesse usually align with one or more components of the main villa block. At the Villa Emo, to cite an example, the balustrade of the loggia’s columns align with one of the bands of the main villa block’s base and the bands at the imports of the barchesse’s arches align with a band at the top of the main villa block’s base. In another example, in the executed Villa Badoer, the tops of the columns of the barchesse align with the top of the main villa block’s base (Note that in the executed version the barchesse have two storeys whereas in the Four Books they have only one.).

As for the possible alternatives in which to arrange the barchesse in plan, it is possible to conceive a computer program such as Hersey and Freedman’s, which would draw the alternatives. In view of the greater uncertainties regarding Palladio’s intentions for barchesse, the approach adopted was to deduce the obvious rules from the designs of the barchesse depicted in The Four Books and reproduced in Figure 12 (Built works were not considered because few of the barchesse were built in their entirety.). After selecting what was deemed to be a combination of design parameters suitable for the above casa di villa, barchesse were designed and modelled with the GDS solid modeler.

Prior to a critique of the barchesse as modelled with GDS, let us briefly examine the variables which were considered in selecting a design for the barchesse and some evidence for them. First, there is the overall shape of which Palladio’s barchesse exhibit three types: a) rectangular or L-shaped in plans, with two L-shaped wings projecting from either side of the main villa block as in the Villas Zeno, Angarano, Pisani at Ragnolo, Saraceno and Ragona, b) curved, with a curved portico extending out from either side of the villa to meet rectangular barchesse as at the Villa Badoer or the Villa Thiene, c) a linear arrangement which extends from either side of the main villa block and which displays a loggia in a plane parallel to the front elevation of the villa, as in the Villa Emo or the Villa Barbaro (excepting the rear of these barchesse which show small wings projecting back) and d) a combination of curved and rectilinear as at the Villa Trissino.

Another variable is the place at which the barchesse attach to the main villa block. There are four possible attachment points: a) at the side of the main villa block near the front elevation in the case of the Villa Emo, b) at the side of the main villa block near the rear elevation in the case of the villas Zeno, Angarano, Saraceno, and Pujana, c) behind the main villa block as in the case of the Villa Barbaro and d) in front of the villa so that the loggias lead directly from stairs emanating from the sides of the entry portico to the barchesse as at the Villa Badoer.

The manner in which the barchesse attach to the main villa block may also be classified. There are two categories, a) direct attachment, as in the case of the villas Saraceno and Barbaro, where the barchesse abut the main villa block and b) where only the loggia in front of the barchesse extends to abut the main villa block as
Figure 15: Modeled eye level View of the Orchard and the Rear Façade of the Casa di Villa.

Figure 16: Modeled Elevated View of the Orchard and the Rear Façade of the Casa di Villa.
in the case of the villas Zeno, Angarano, Pisani at Bagnolet, Ragaia, Poiana, Thiene, Badoer and Emo (As built the Villa Emo would be classed as a).

Lastly, there is a variable describing the orientation of the barchesse, whether they define a cortisio in front of or behind the main villa block. The more frequently used orientation is such as to define a cortisio in front of the main entry as in the case of the villas Sarsceno, Ragnaia, Pojana, Barbaro, Thiene, Badoer, Emo and Trissino. Cases with reverse orientation are the villas Pisani at Bagnolet, Zeno, Angarano, judging from the location of the recessed portico which is probably the main entrance. In all there are, therefore, four variables providing two choices for orientation, four for shape, four for the place of attachment, and two for the type of attachment, giving a total of sixty-four alternatives. The alternative which was chosen has a normal orientation, is curved in shape, is attached at the front portico, and is attached indirectly to the main villa block. Although the design variables for Palladio’s barchesse as just enumerated determine an overall layout, they do not prescribe the height or the depth of the barchesse or of the related loggia enforcing it not to mention the spacing of the columns in the loggia. No obvious rules for these latter variables could be discerned other than a discussion by Wittkower on the plausibility of the barchesse’s dimensions completing certain harmonious sets of dimensions appearing in the main villa block. Judgement based on a visual review of Palladio’s designs including, in particular, one built set of barchesse, those of the Villa Badoer, was used to determine those variables. In practice, Palladio would no doubt have been influenced in his choice of configuration by the shape of the lot on which to locate the villa, the direction of access to the villa from the road and water, the size of the land holdings managed by the owner and the number of workers to be accommodated in the barchesse.

Critique of the Barchesse.

Figures 7 and 10 show the three-dimensional model of the first scheme for the barchesse reflecting the choice of design parameters just discussed. By visual comparison with Palladio’s built and unbuilt works, the barchesse seem small in relation to the size of the loggia and probably also in relation to the size of landholdings the owner would likely possess. Another problem with this scheme is that the ends of the barchesse do not reach to the wall enclosing the cortisio at the north side (see section on gardens for the layout of the cortisio). Palladio’s barchesse usually form part of the enclosing walls on two sides.

As a result of these perceived un-Palladian limitations, a second model of the barchesse was created in which the barchesse have been lengthened. The second scheme is shown in Figures 9 and 11. Even this design is not entirely convincing because the length of the loggia seems extravagant in relation to the size of the casa di villa. Perhaps the loggia should terminate where the barchesse proper begins. For lack of time this alternative was not considered further.

Also for lack of time, some additional un-Palladian detailing was permitted to remain in the model. This includes an entablature above the columns of the loggia which has no perceivable architrave and a spacing for metopes and triglyphs which does not follow the rhythm of the column spacing.

Gardens.

When introducing villas in the second of his Four Books, Palladio declared that “pleasure gardens and kitchen gardens are the sole and the chief recreation of the villa” (Palladio/Ware, 1735). Not surprisingly, therefore, the layout of the gardens was considered more important than the architecture of the villa (Hobberton, 1990e). This is difficult to appreciate because today all of Palladio’s villas are missing this important aspect. Gardens appealing to all the senses with a plethora of perfumed aromas, a rich tapestry of green foliage accent by bright flowers of all kinds, vines and jasmine nurtured on trellises, the sound of splashing water dripping from fountains surrounded by topiary and no doubt numerous singing birds happy to pass the time in such an earthly paradise. In fact it was exactly as an earthly paradise that gardens were seen as attested to by the original meaning of the word garden which was paradise (Murray, 1975; Lazzaro, 1990).
Figure 17: Bird's Eye View of a Possible Palladian Villa (Orchard Garden Trees Removed).

Figure 18: Modeled View of Cortico and Main Entry Portico as Seen Through the Gate of the Cortico.
To judge only from the scant evidence we have of the gardens which surrounded Palladio’s villas and of the gardens which preceded Palladio’s villas, such as the Villa Giustinian, it appears that Palladio’s gardens fit the general mold of what is known of Renaissance gardens of the 16th century. Hence a brief excursion into the nature of Italian Renaissance gardens of the 16th century is appropriate.

The Italian Renaissance garden, known as orto in general and as giardino, if the garden was more dignified and graced with fountains, say, always had three components which corresponded to subdivisions of the natural world into three types of plant material (Lazzaro, 1990a). These were the bosco, a wood or grove of large trees, the orchard, consisting of fruit trees on grassy plots scattered with low-growing herbs, and the garden planted with herbs, simples (plants with medicinal uses) and flowers. Every Renaissance garden contained each of these components to a greater or a lesser degree as it was deemed essential to the completeness of the garden. Lazzaro provides a detailed account of the types of plant material in each part of the garden (Lazzaro, 1990c).

Renaissance gardens were surrounded by high walls, concealed with climbing plants on trellises, or hedges of dense mixtures of shrubs including thorny ones. Tall hedges also subdivided the three major parts of the garden. The garden thus defined on the perimeter was then subdivided into a sequence of squares to form a grid pattern (that is, grids underlay both the design of gardens and of architecture). Paths lined with hedges, low trellises with vegetation trained on them or trees demarcated the squares. Principal paths were sometimes covered with pergolas. These squares or compartments were the essential element of every Renaissance garden.

In the area of the garden devoted to simples, herbs and flowers (also known as orto), the compartments were further subdivided into geometric shapes. Each compartment might be surrounded by a low hedge punctuated by two to eight fruit trees around the perimeter and subdivided into geometrically shaped compartments containing different kinds of vegetables, herbs and flowers.

Within the Renaissance garden may also be found, usually bordering on the main villa block, a purely ornamental section of the garden consisting of squares of topiary in the shape of labyrinths and other geometric figures, the whole punctuated by one or more fountains. In fact, an important element of the Renaissance garden was both nature made by man into ornament and man-made ornaments such as fountains, pergolas and grottos. Water was everywhere connecting the various parts of the garden sometimes erupting in unusual ways to surprise unsuspecting visitors. These surprises were known as giochi d’acqua (Holberton, 1900).

In other parts of the garden there were rectangular compartments of fruit trees in rows comprising the orchard component of the garden and in still others, more remote from the main villa block, the bosco consisting of rectangular compartments with rows of tall trees.

Combining what we know of Renaissance gardens together with what we know of the Villa Giustinian (Figure 1) allows one to conjecture as to what the gardens surrounding Palladio’s villas must have been like. As at the Villa Giustinian, the bosco would have been external to the walls surrounding the villa compound, which for the purpose of this study was chosen to be rectangular in shape with the long dimension along the North-South axis. There is a main gate with substantial gate posts in the walls at the north end and a south gate incorporated into a garden pavilion on whose upper level, beneath a vine-covered trellis, the owner’s family and guests could have outdoor meals. The orchard is behind the main villa block in the area shown on the plan for the Villa Giustinian as the brolo piccolo. At our possible Palladian villa the orchard is therefore located between the pavilion and the main villa block. The orchard consists of grass-covered rectangular compartments, bordered by box hedges and enclosing rows of fruit trees with gravelled walks between the compartments. Figure 14 provides a view of part of the computer model of the orchard showing fruit trees and the pavilion from the view-point of a person within the orchard. Other views of the model showing the orchard and the south side of the main villa block are shown in Figures 15 and 16. The bosco is indicated in the model by the rows of Cyprus trees to the south of the villa just outside the walls in Figure 14.
Figure 19: Modeled Elevated View of Cortizo and Main Entry Porico.

Figure 20: Modeled Eye Level within Cortizo of Fountain, Portico and Trees.
Figure 21: Modeled Wide Angle View of the Cortile Showing Loggia Leading to Barchesse, both Fountains and Tree.
Figure 22: Roof Plan of the Possible Palladian Villa and the Garden
garden for flowers, herbs and simples is located, as it is at the villa Giustinian, on either side of the main villa block, in this case, enclosed by walls running between the main villa block and the outer walls. It too consists of rectangular compartments demarcated by low box hedges but within the rectangles are geometrically shaped beds of flowers, herbs and simples and some fruit trees. The garden compartments may be seen in the overall view of the model of the villa in Figure 17 and in the plan in Figure 22. Detailed views are not shown because a more developed representation of this part of the garden with, for example, approximations of flowers and small bushes was not attempted.

The cortivo is the space embraced by the circular loggia, the barchesse and the north wall. This is the space visitors find themselves in on entering through the main gate and where tenants enter to call on the owner or to deliver rent in kind. In all likelihood, the cortivo served as the setting for a formal garden consisting of rectangular compartments of topiary in the form of masses and other geometric shapes punctuated by fountains. Both the Villa Barbaro and the Villa Badoer provide evidence for such formal gardens because the fountain bases can still be seen at the former while at the latter, the fountains are still present. Figures 18 to 21 show views of the cortivo as modelled for this study. Two poplar trees stand inside the cortivo at locations inspired by the two large trees in the cortivo of the existing Villa Badoer. Two large compartments defined by and containing topiary in geometric shapes on reddish gravel (as at the Villa Lante), each with a fountain at its center, define the rest of the cortivo. Four small trees in terra-cotta pots (two are visible in Figures 18 and 21) were also added.

Critique of the Gardens.

It is probably fair to say that the virtual reality of the casa di villa in its garden setting is convincing and evocative of what one would have experienced on the grounds of a Palladian villa of this type in the sixteenth century. It is a convenient fact of visual perception that abstracted rather than fully detailed reality is sufficient for it to be convincing as long as the viewer is adequately far away from the details. This is the saving grace in the virtual reality of the possible Palladian villa because a certain amount of abstraction was still necessary insight of the considerable computational power available from the Digital Equipment DEC Station 5000 used for the renderings because of current limitations of swap space for memory on the hard disk storage devices. Among these abstractions was the limitation on the number of branches and leaves per tree which could be rendered and the consequent decision to increase the size of the leaves at the expense of their number. The abstraction of topiary and Cyprus trees as extrusions and objects of revolution, respectively, was reasonably successful as well.

Unlike the casa di villa and the barchesse, it is not possible to do a visual comparison of the gardens with Palladian precedents because none exist. Hence the following is simply a noting of deficiencies, which only became apparent on visual inspection of the model and which, if rectified, would lead to a more convincing modelling of the gardens. Start with the garden. The pavilion could be improved with balusters in the upper railings, round columns rather than square posts supporting the trellis and some leaves on the trellis. Currently all the trees in the orchard, which are identical for simplicity of modelling are oriented the same way. If the trees were randomly rotated it would be difficult to recognize that all trees are identical. Even in the current model, this is evident only in certain views. The walls around Renaissance gardens were usually covered with vines and had various plants trained on them. Although the number of leafy plants which can be modelled in a garden is limited, perhaps flat, green, extruded, solid objects with undulating upper surfaces could be set against the wall to give the appearance of vine-like plants. A detail which could also add realism might be to raise the level of the grass in the orchard’s compartments above the level of the walks.

The gardens for herbs, simples and flowers could benefit from additional detail. These include some fruit trees in each compartment, a simulation of flowers, perhaps with colored disks randomly arrayed over some of the beds and some simplified bushes generated with the same algorithms as used for the trees. Without such detail, this part of the garden can only be viewed from large distances because all the beds are green, extruded, solid objects.
Figure 23: North Elevation of the Cortico and Main Portico of the Possible Palladian Villa.

Figure 24: South Elevation with Orchard of a Possible Palladian Villa (South Garden Wall Removed).
The cortico, like the orchard, is reasonably successful despite the limitations of computer software and hardware. The only improvements which immediately come to mind might be some additional and larger potted trees, perhaps lemon trees with bright, yellow lemons. Also, the topiary, which is presently all the same height, might include some large cubes or spheres.

Finally, the bosco could be made more imposing by extending the row of Cypress trees in either direction from the garden pavilion. A possible alternative would have been to consider scanned and digitized photographic imagery for the bosco. Such an attempt would run the risk, however, of making the viewer more aware of the abstractions in the computer model thus contributing to a less convincing virtual reality.

Computer Tools.

The software which was used for the three-dimensional modelling of the possible Palladian villa consists primarily of three modules of McDonnell Douglas’ GDS software namely, the Solid Modeller, XSOLID, the Assembly Modeller, XPAM, and the Scene Viewing System, XSVS. The model of the main villa block and the Barchesse were created with the VMS version of GDS running on a shared Digital Equipment VAX Station 5000 with Tektronix 4115 and 4125 displays, while the gardens and renderings were executed with a beta test copy of the Ultrix (Digital Equipment’s version of the Unix operating system) version of GDS running on a DEC Station 5000, rated at 25 MIPS and having 48 MB of main memory and 150 MB memory swap space in the form of disk storage. Files of three-dimensional objects were transferred between the VMS and Unix systems in the form of Things files which are ASCII text files.

The models of the main block, the barchesse and the wall were developed by three students working simultaneously. The solid objects of which the models were composed were created in the Solid Modeller, positioned in their correct coordinate locations, if this was known, and stored as components in files known as Codices. Components which depended on the location of components created by another student were correctly positioned in the Assembly Modeller. This was accomplished by setting up in the Assembly Modeller windows of views (planes, elevations) of the work of all the other students and therefore the current state of the villa. The Assembly Modeller was also used to array components in linear or circular arrays. This was useful for creating the loggias associated with the barchesse. Other operations involving copying or moving multiple groups of components were also accomplished in the Assembly Modeller because the Assembly Modeller’s strength is in the manipulation of solid objects while the Solid Modeller’s strength is in the creation of solid objects. The views created in the Assembly Modeller, which are projections of the three-dimensional model, were used to create some of the detailed line drawings such as plans, sections, and elevations of the villa. Others were created directly as plots of scenes in the Scene Viewing System. Figures 22 to 26 show these drawings. The projected drawings could have been elaborated with further detail (for example, a relief in the pediment of the main entry portico) using the two-dimensional drafting functions of the XGRAPHIC module of GDS for details considered too time-consuming to create in three dimensions. The Assembly Modeller and the Scene Viewing System allowed the three-dimensional model of the villa to be used as a data base for the automatic production of drawings reflecting the current state of the design.

The modelling strategy for the gardens deserves special mention. This was developed by the author and carried out with the assistance of a fourth student. The two poplar trees in the cortico and the potted trees there as well as the trees in the orchard were generated outside of GDS with a TREE program from ARC Yamaiga in Japan which runs on the VMS operating system. The program uses an algorithm for repetitive branching to create the trunk and branches and algorithms for the placement of leaves and blossoms of user-specified shapes. Although it is possible to design trees from basics by supplying branching angles and the shapes of leaves, for instance, it was decided to adapt the files for creating specific species of trees which are supplied with the program. Thus the poplar trees have their leaves enlarged two times to achieve a greater effect with fewer leaves and the trees in the orchard, which are modified cherry trees, had their leaves
Figure 25: South Elevation of a Possible Palladian Villa with Garden Pavilion (South Garden Wall Removed)

Figure 26: North-South Section of a Possible Palladian Villa with Gardens above and East Elevation of a Possible Palladian Villa (East Wall Removed)
enlarged eight times and the trunk and branches thickened by a factor of two. The output of the TREE program is in the form of Things files which can be read directly into the Solid Modeller or the Scene Viewing System. Actually, only the files representing the trunks and branches can be read into the Solid Modeller because they are solid objects. The leaves and blossoms are isolated surfaces and can thus only be read into the Scene Viewing System. Groups of leaves for each tree were therefore individually placed in position in the Scene Viewing System until a group of trees, representing say, a compartment in the orchard, was complete and could be saved as a scene for later recall for rendering.

Conclusions.

This study has contributed in the following ways to computer-based historiography in general and to the history of Palladian villas in particular: As a result of applying the method of visual criticism at the level of the abstracted reality of two-dimensional plans and elevations in the manner used by Hersey and Freedman, design rules for Palladian villas are presented which go beyond those of Freedman and Hersey. At the same time the earlier work on shape grammars for Palladian villa plans by Stiny and Mitchell is reexamined and placed in the context of Hersey and Freedman’s work. The problem with the earlier work is that it does not go far enough in enumerating uniquely Palladian plans but it provides a useful method of classification. Design principles are presented for Palladian barrel vaults and for the Renaissance gardens surrounding his villas. Hersey and Freedman’s method of visual comparison is then extended to three dimensions by creating a three-dimensional model based on a plan generated by their program which satisfies the additional rules discovered in this study for Palladian villa plans. A number of un-Palladian features are exposed in the three-dimensional model of the main villa block and the barrel vaults implying additional Palladian design rules at a more detailed level.

These contributions have demonstrated, it is hoped, that computer-based generation of plans and elevations in a particular style, such as Palladio’s, and their elaboration into three dimensions is not so much a method of design as a method of criticism and consequent understanding. As one generates designs, errors in the underlying assumptions (rules) become immediately perceivable to the eye as well as the need for additional design rules. To mention only one conceivable rule in the final three-dimensional design of the possible Palladian villa, should the height of the columns in the portico be larger than those of the loggia leading to the barrel vault in order to place greater emphasis on the entrance? Only in one of Palladio’s early works, the Villa Pisani at Bagnolo, are the columns of the portico and the loggia the same height.

The approach used in this study provides a method of studying architectural history where, instead of being a passive observer of historical accomplishments unaware of the real issues motivating these accomplishments, the student is able to experience, like our ancestors, which of all the possibilities open to us are relevant for our consideration and action. This paper is therefore an attempt to display images of a virtual reality, a reality recreated from the past into which the student of architectural history can project himself or herself.

Although this virtual reality must be convincing enough when it is created in three dimensions to engage the student’s commitment, it is demonstrated that a slightly abstracted three-dimensional reality in the area of algorithmically generated plant material, which was necessitated by limitations in rendering power available to the author, is acceptable. Lastly, this study contributes to the pedagogy of computer-aided design. This study was, in fact, conducted as a pilot project for a new course in computer-aided design in which the study of architectural history is a means to understanding and using computer-aided design at two levels, one, at the level of design criticism already noted, and two, at the level of using computer-aided design software as a data base of two and three-dimensional information which can be used to extract all manner of drawings and images. An important part of the course includes, therefore, the structuring of the data represented by the three dimensional components of which complex models such as the possible Palladian villa consist.
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