Contribution to "Festschrift for Arthur Jampolsky" (A.B. Scott, Ed., 2000)

Perspective as a Geometric Tool that Launched the Renaissance

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Depth representation, in both its geometric and its more generic forms, has often served as an impetus in artistic development through the millennia. The first historical mentions of art, by Plato and contemporaries in the 5th century BC, were provoked by the dramatic use of perspective in the scenery for the plays of Aeschylus and Sophocles. One of these innovative scene painters, Agatharchus, even wrote a commentary on his use of convergent perspective, whose effects had inspired several contemporary Greek geometers to analyze the projective transform mathematically.

No examples of Greek perspective paintings survive, but we can perhaps glean a sense of their technique from Roman copies (probably by Greek painters) from the ruins of Pompeii in the first century AD. The example shown in Fig. 1 gives a vivid impression of a three-dimensional portico as a backdrop to the myth of Orestes. The depth is conveyed by shadows an interposition as well as the linear perspective of the angles of the horizontals. By the principles of central projection, all horizontal structures running into the distance away from the plane of the picture should project to s single central vanishing point. Little (??) has argued that painting from this period does show accurate adherence to this perspective principle. We may test this idea by performing a careful analysis of the projection geometry of all the receding horizontals. Such an analysis is illustrated in Fig. 1.

The black construction lines illustrate that the central structures adhere accurately to a single vanishing point close to the viewer's eye level (estimated as horizontal light line). The light construction lines drawn from the rafters in the roof visible at the upper right, and from other edges distant from the center, illustrate that there was no principled adherence to a central vanishing point. The lines from distant receding horizontals are in roughly parallel perspective in each quadrant, giving a reasonable impression of appropriate perspective but betraying a lack of understanding of the core geometric principle. This level of ability (which is typical of the era) implies that the Greek and Roman painters could evoke astonishing levels of three-dimensionality in their murals but did so from an intuitive grasp of the convergence concept rather than a fully accurate construction.

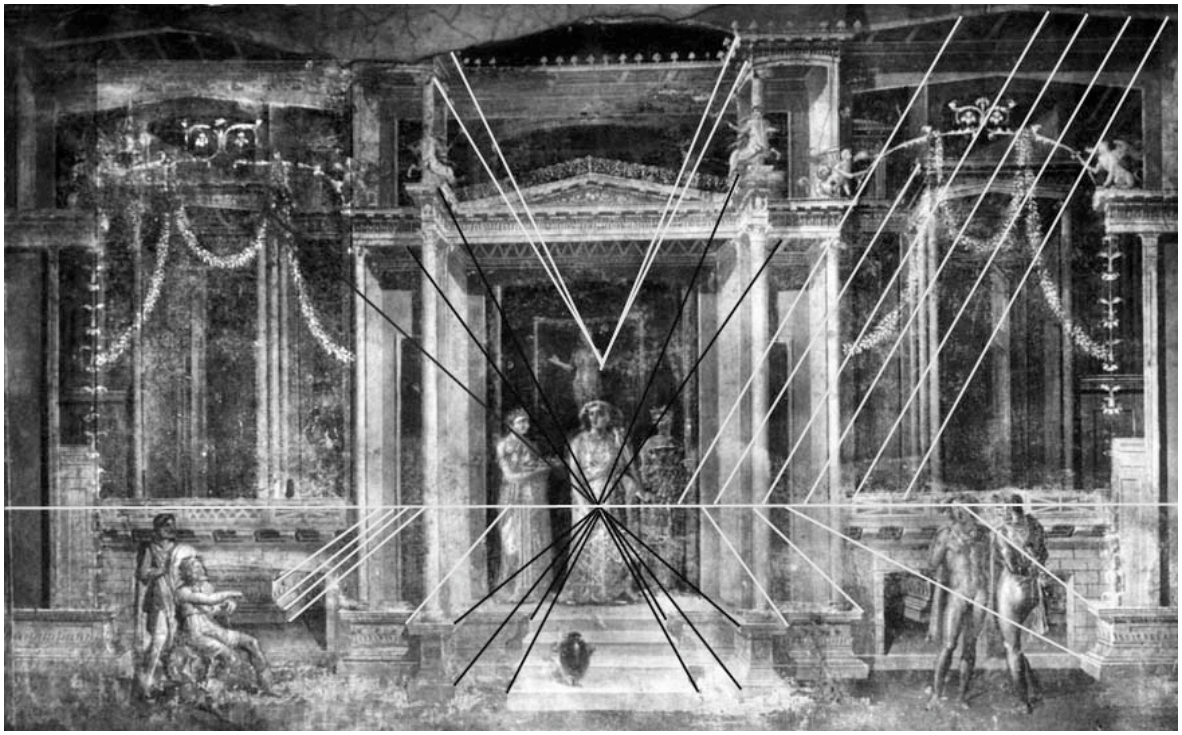

Fig. 1. Pompeiian mural of the pageant of Orestes, 2nd century AD, containing both central convergence (black lines) and 'fishbone' parallel convergence for the peripheral features such as the roof rafters (white lines).

Not only in the Roman era, but subsequently in the 14th century, painters such as Cimabue, Giotto and the Lorenzetti brothers were struggling with the concepts of linear perspective. Evidently aware of its profound visual impact, their progress toward a more coherent approach to geometric perspective seemed to spark the eloquent visual representation that is the hallmark of Renaissance art. One of the first uses of perspective was in Giotto's 'Jesus Before the Caïf' (Fig. 2A), more that 100 years before Brunelleschi's perspectival demonstrations galvanized the widespread use of convergent perspective of the Renaissance proper.

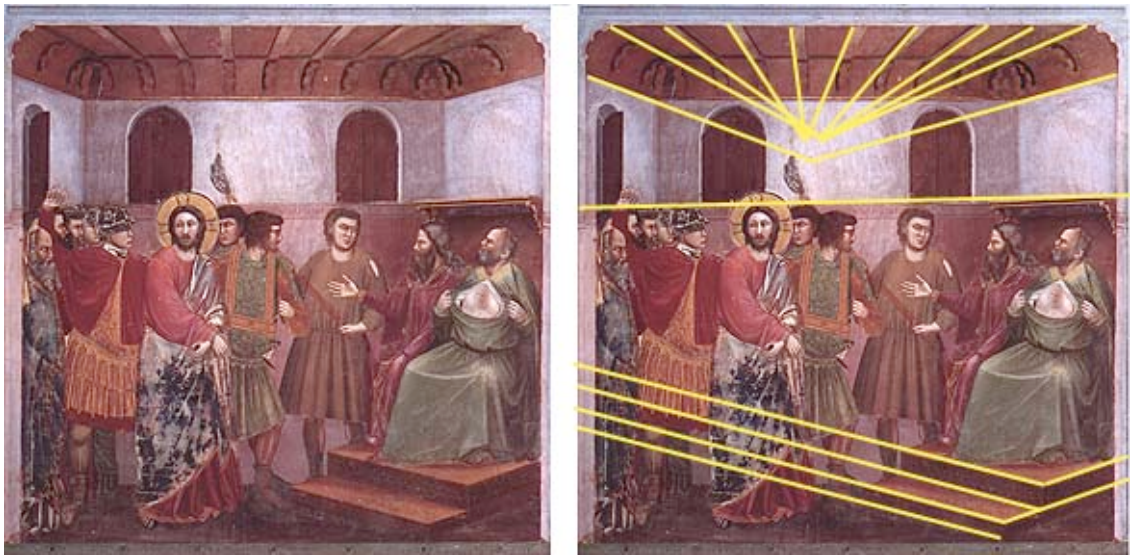

Fig. 2A. 'Jesus Before the Caïf', by Giotto (1305). The ceiling rafters show the Giotto's introduction of convergent perspective. B. Detailed analysis, however, reveals that the ceiling has an inconsistent vanishing point and that the Caïf's dais is in parallel perspective, with no vanishing point.

Geometric analysis reveals that Giotto had implemented the idea of convergent parallels without the use of an accurate vanishing point. The rafters in the ceiling all converge convincingly, but geometric projection exposes the failure to converge accurately. The deviation is scarcely noticeable in the original fresco, so Giotto had a good eye in this instance. The minor misconvergence is, however, sufficient to document that Giotto did not use a vanishing point in his construction of the ceiling. His dramatic evocation of depth in this picture was therefore based on either a non-geometric construction principle or a different form of construction that did not involve the use of vanishing points.

Inspection of the picture also shows that there is a curious bowing of the back wall forward, both implied in the wooden cornice and induced by the shading on the stucco wall. The main reason for the bowing of the cornice seems to be that the rough vanishing point for the ceiling is much higher than for the shelf at right, which should also project to the same location (see Fig. 2B). This discrepancy reveals that the convergence of the beams is steeper than is required by accurate geometrical perspective.

The bowing of the wall is a separate issue that seems to be due to the symmetrically graded shading. The two windows, for example, have symmetrically opposed highlighting that may be accurate if lit by a central window on the near wall, but seems to add to the perceived curvature from the wall shading. Nevertheless, it is odd that the two effects conspire to produce a uniform distortion of the whole wall.

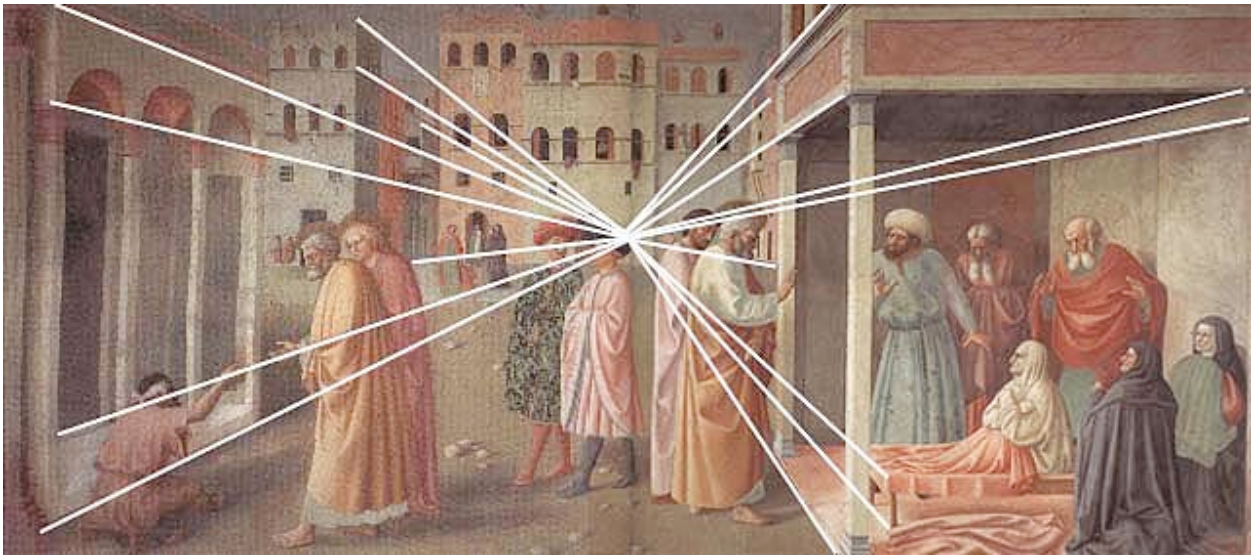

Fig. 3. 'The Healing of the Cripple and the Raising of Tabitha', by Masolino (1425). Note the accurate central convergence of structures from the front of the canvas to the far distant background.

Throughout the 15th century, the new tool of linear perspective was employed by artists with verve to enliven their visual story-telling. The first known use of accurate central convergence was by Masolino in 1425 (Fig. 3), in a picture that is telling two separate stories. Note the integration of the perspective of the left and right sides of the scene, both interior and exterior lines, their integration with the convergence of the streets on the left and right sides of the background, and the placement of the vanishing point at the eye height of the standing figures (where it must be if the viewer was standing in the same plaza). This degree of complete integration can only be achieved by an explicit implementation of the concept of a central vanishing point (unless, of course, there were optical projection of the flat scene onto a picture plane, which seems unlikely for a fresco such as this work). It seems clear that Masolino had understood, for the first time, the power of the vanishing-point construction in depicting visual space.

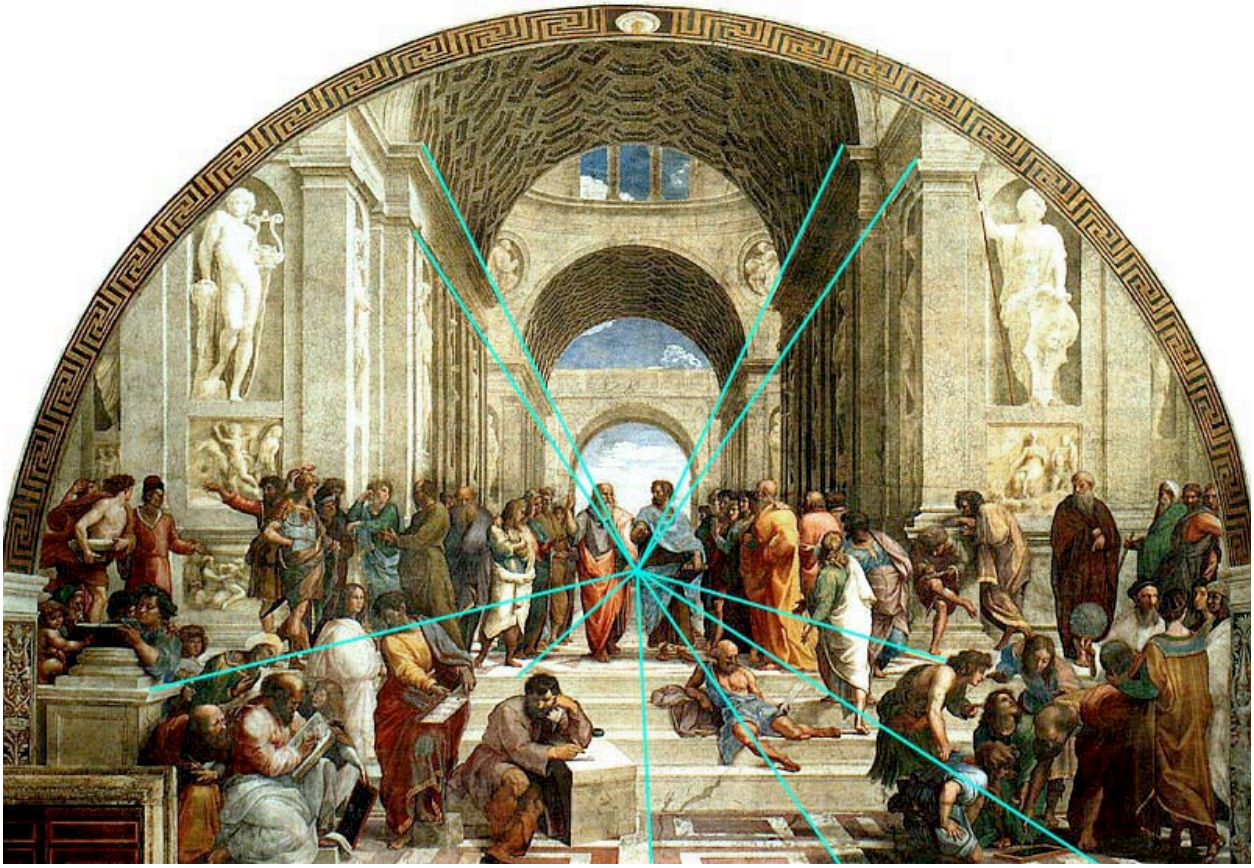

Fig. 4. 'The School of Athens' by Raphael (1505), a fine example of architectural perspective with a central vanishing point, marking the end of the classical Renaissance.

It is surprising, therefore, to find that almost all Renaissance examples relied on the simple one-point perspective scheme. They never broke away from the concept of a principal vanishing point governing a rectangular grid on which the architectural elements were constructed. One of the prime exponents was Raphael, whose 'School of Athens' fully displays the architectural grandeur that could be achieved with this method, as a background for his evocation of the pantheon of ancient Greek philosophers. The central vanishing point is at Socrates left hand, close to the eye height of the standing figures in front of the steps, and just where it should be if the viewer was standing with them on the lower floor.

Throughout this period, artists had toyed with the location of the 'central' vanishing point, seemingly unaware that it should be directly in front of the viewer's eye for the painting to be in correct perspective (presumably in the lateral center of the canvas, at a height appropriate for a typical viewer). In any other position, the perspective projection would be distorted and the depth impression either reduced or skewed. An extreme case of such an offset is Carpaccio's 'Disputation of St Stephen' (Fig. 5), where the vanishing point is actually outside the canvas to the right. Of course, the painter may choose to angle the structures in the scene at any desired slant, so there is no inherent problem with having a vanishing point near one side of the canvas. The problem is that, if this choice is made, a second vanishing point is required for lines (horizontally) at right angles to the first set (assuming that the viewer does not also move over to the right to be in front of the displaced vanishing point. This is the oblique, or two-point, perspective construction of which no example can be found until the seventeenth century. It seems that the one-point construction was the only known approach to perspective for the three centuries of the Renaissance.

Fig. 5. 'The Disputation of St Stephen' by Carpaccio (1514). This composition has a single vanishing point beyond the right edge of the canvas. Lines orthogonal to these receding lines are shown parallel to the canvas, with no second vanishing point, giving the building the look of a parallelogram. This construction would have to be viewed from directly in front of the vanishing point for the perspective to be visually correct.

'The Disputation of St Stephen' is typical of the entire Renaissance in retaining the parallels for the transverse lines when the vanishing point is shifted over to the right. These transversals are captured in this instance by the horizontal supporting struts under the arches (and also the line of the bases of the nearest pillars). The horizontals would be parallel to the canvas if the vanishing point were centered, but should rotate back at the left side when the vanishing point is shifted to the right. The horizontals should then converge to an appropriate vanishing point at right, but this necessity was not evident to any of the Renaissance artists surveyed. To retain the parallelism when the vanishing point is shifted corresponds to the depiction of a rhomboidal rather than rectangular building plan (like the John Hancock Building in Boston, for example). The perspective is accurate for this unusual kind of architecture, but it is most unlikely that the Renaissance artists were intending to depict such structures. In fact, they had a rule that the vanishing point could be safely displaced but not beyond the boundary of the picture frame. This rule implies an awareness that extreme displacement incurred distortions, but that the distortions were hardly noticeable within some limited range.

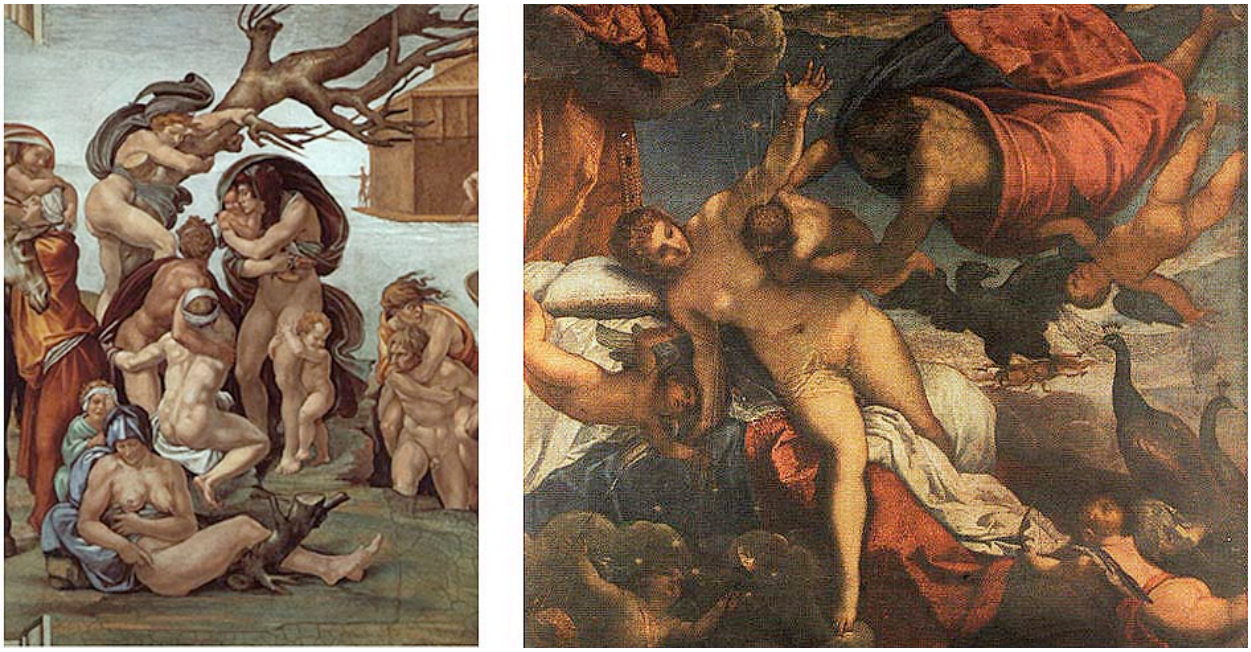

Fig. 5 A. 'The Flood' by Michelangelo (1510). B. 'The Origin of the Milky Way' by Tintoretto (1570).

As the 16th century progressed, it appears that artists felt straight-jacketed by the central perspective scheme, without realizing the flexibility that would have been allowed by full perspective with arbitrary vanishing points. To a large extent, therefore, linear schemes were avoided in the 16th century in favor of spaces populated by classical figures adorned in flowing garments. Where architectural perspective was shown, it was generally suggested, rather than defined, by local fragments of perspective, so that the effects of two-point perspective could be obtained without committing to the geometric solution of its analysis. There is extensive exploration of the three-dimensional visual space, but it is done with shading and foreshortening, avoiding the use of linear structures that would define and constrain the spatial development. Two examples of this approach are shown in Fig. 6, Michelangelo's 'Noah and the Flood' and Tintoretto's 'The Origin of the Milky Way'. The emphasis now is on the expression of heroic emotions through the implied movement of the figures through space, with a fuller deployment of the bodies and limbs throughout the height and depth of the canvas. There is no lack of the use of space, but the perspective effects are achieved without the use of linear perspective and the complications of its rigid geometric laws.

The emphasis on figural perspective lasted for two centuries, but new impetus in art was given by the appreciation of the two-point perspective construction in the 18th century. Stimulated perhaps by the vivid angular perspective in Bibliena's theatrical scene-painting, artists such as Poussin, Canaletto and Piranesi made bold forays into new forms of perspective construction. Led by a few specialists from the mid-17th century, eighteenth century art finally discovered the flexibility to introduce vanishing point in any direction at the whim of the artist, making extensive use of the oblique perspective construction. The classical revival was under way, leading to the gothic style that characterized 19th century art. Once again, the geometric techniques of depth evocation played a role in the evolution of artistic aesthetics.

One example of the style is 'The Temple of Concordia' by Piranesi (Fig. 6), one of his series of etchings on the ruins of ancient Rome (which are still viewable today). It is obvious that oblique vanishing points to left and right have replaced the central vanishing point of the Renaissance, although this simple modification was not appreciated for 200 years after the central perspective

came to the fore. The late 17th and 18th centuries finally saw effective control over the two-point perspective construction that seemed to have eluded the artists of previous epochs.

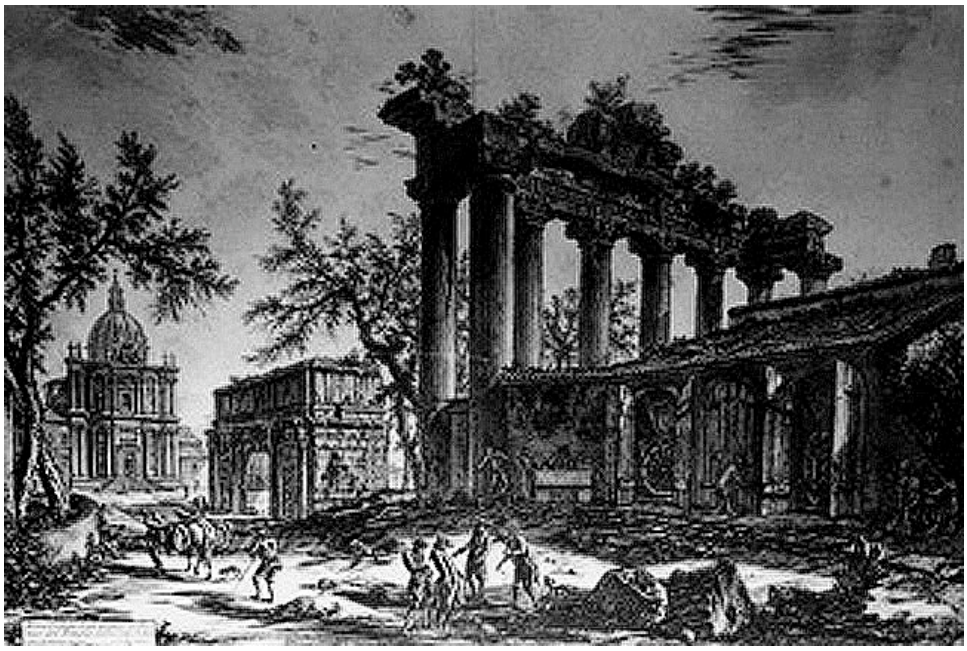

Fig. 6. 'Another View of the Remains of the Pronaos of the Temple of Concordia' by Piranesi (1774).

Conclusion

This brief survey has sketched the outline of spatial representation over two and a half millennia. It is the story of a struggle between inspiration and geometric analysis. For much of the period, geometry was regarded with the highest appreciation and yet the human mind was unable to get an adequate grasp on the intricacies of this construction. Even though the central perspective construction may have been perfected by the master exponents, attempts to employ a more flexible construction seemed to be limited and rigid. The few mathematical treatises that explored new modes of perspective failed to distill them down to rules that could be employed by artists. Nevertheless, the interplay between the power of perspective and the difficulty of its implementation seems to have been one of the motivating forces through the Renaissance and beyond. Even in the twentieth century, when perspective conventions were disregarded or elaborated beyond recognition, the effects have often played off the yoke of perspective realism that came to dominate most 18th and 19th century art. For or against, perspective has been a major theme throughout the history of Western art.