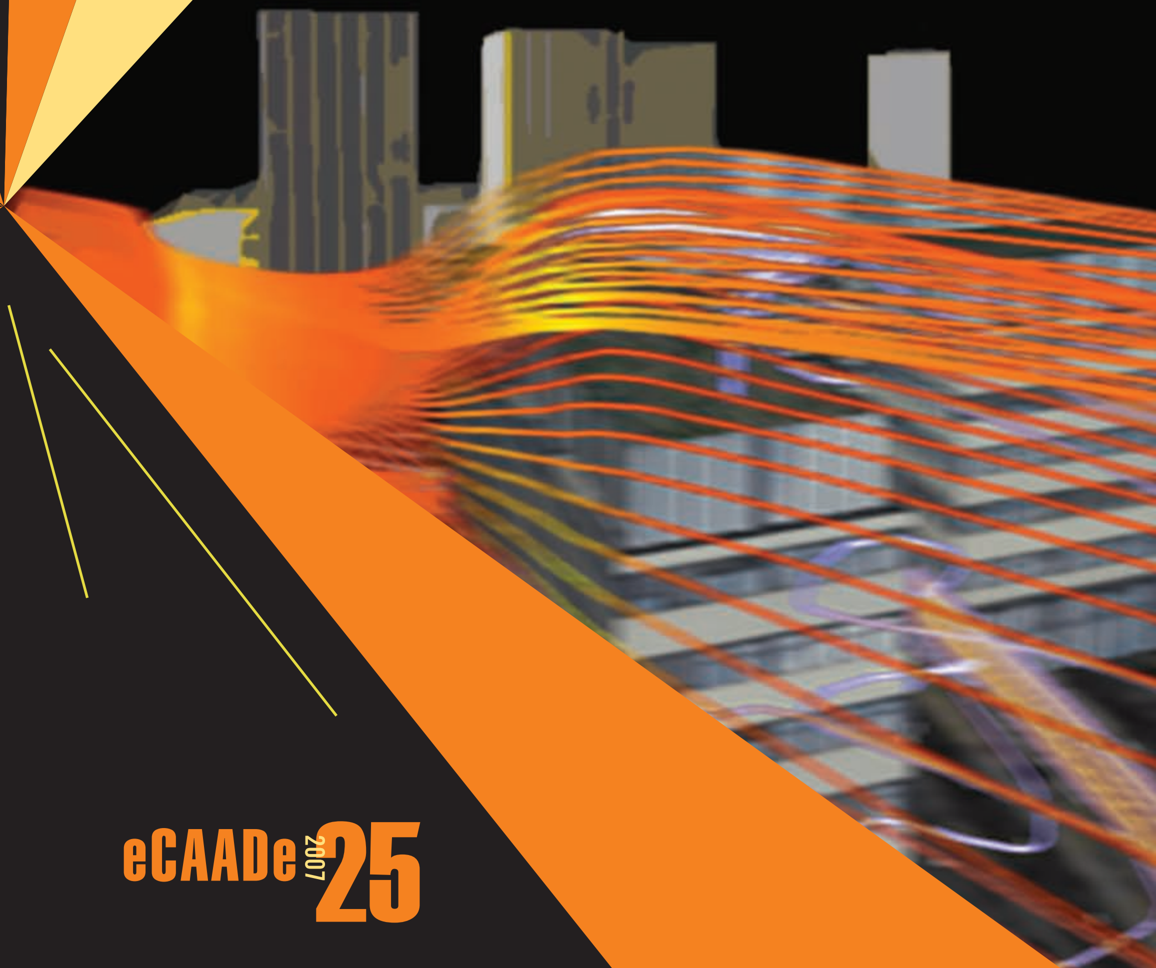
PREDICTING THE FUTURE

EDITED BY JOACHIM B. KIEFERLE AND KAREN EHLERS



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We are first of all indebted to the authors that honour this publication with their work as well as to the keynote speakers, Alexander Rieck and Paul Seletsky.

The work of the international team of reviewers was instrumental to review each of the more than 220 submitted abstracts by three independent reviewers which sums up to over 660 reviews. We had a very high quality of abstracts, so the reviewers judged more papers publishable than we were able to accept for the conference due to various limitations. We apologize for omitting the papers that we were not able to accept. Based on the reviewer's recommendation, the eCAADe council was a great help in the decision process.

The reviewers for eCAADe 2007 were:

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During the whole preparation eCAADe president Henry Achten and, the ever-so-helpful conference liaison, Bob Martens were always available when needed!

A conference like eCAADe can only be held with the best organizing and scientific team: Andrea Benk, Martin Hoeglund, Frank Salffner and Ulrike Seeber as well as the best student helpers of our schools Isabel Baumgartner, Thomas Böhm, Jessica Heym, Karl Horrer, Franziska Kinsukoin, Anna Stone, Verena Warrlich.

We express our gratitude to the companies supporting the conference with their donation: Bentley Systems and AutoDesk, and those supporting the accompanying social events: the Monestary Eberbach and the "German Architecture Museum" (DAM). The support of the Deutsche Forschungsgemeinschaft (German Research Foundation - DFG) is essential for the high quality of the conference.

Finally we would like to thank the presidents of our schools, Clemens Klockner (FH Wiesbaden) and Wolf Rieck (FH Frankfurt) for their commitment to personally support this joint conference and also provide us with all necessary resources.

We shall pass the honour of organizing the next eCAADe 2008 to Belgium, where the first conference was held a quarter century ago in 1983 and look forward to further inspiring research and discussions.

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RQS - Reverse Quadratura for Surveying

Applying Ancient Methods to Digital Techniques

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This research is based on the development of a new method for surveying single and double curved surfaces using an application of an ancient perspective method for representing a picture on a complex surface. The procedure enables the user to have some detailed cross-points of a grid in order to simplify the survey operation. Another phase of the work is to take some double-pictures of the element, according of the method I shall describe in the paper. The photographs of the single element, with the projection of the regular grid, can be processed with every Image-Based Modeling Software in order to obtain – with the usual calibration methods – the digital "mapped with reticulum" model of the curved surface we are analyzing. The final step enables the user to improve the quality of the textured model, switching from the grid-textured photographs to the simple-textured one. This research is part of a more general theoretical and experimental Academic research that has the aim of studying the ancient drawing methods of in order to find some analogies with the digital technology applied to the study of architectural buildings.

Keywords*: Geometric modeling; survey; image-based modeling; image processing; quadraturism.*

On the theory of quadraturism

The perspective method known by the Italian term of "Quadratura" enables the user to simplify the process of drawing bi-dimensional images on a plane or curve surface. It was used between the 17th and 18th Centuries to transfer little sketches of perspective scenes on big walls to be painted. One of the main researcher in this field was Andrea Pozzo (1642-1709), who used this method for the realization of some of his wall-paintings – such as the *Gloria di Sant'Ignazio* or the *Casa Professa del Gesù*, both of them in Rome – but also studied this technique theoretically in order to improve the use of the perspective for the realization of great art masterpieces.

In the image in fig. 1 – that is the illustration N. 100 of his treatise (Pozzo, 1693-1700), entitled *Modus reticulationis faciendae in testudinibus* – there are the plan, the section, the elevation and the perspective of a vault with lunettes.

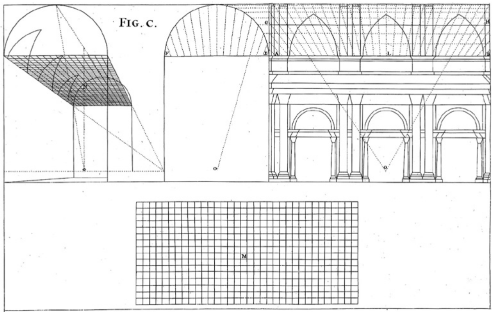


Figure 1
The method of drawing the net-work on vaults, developed by Andrea Pozzo (Pozzo 1693)

A frame of small cords or threads is hung up in order to have a geometrical rectangular grid put horizontally and in a lower position with respect of the curved surface. Pozzo says that if you put a lamp or a candle ("*lumen candelae aut lucernae*") in the night-time at the point O, you can project the shadow of the frame on the vault, and you can trace the grid on the surface using a pencil. Thanks to the omology between the plan of an object and the relative perspective of it, it is sure that every eye – whose function is similar to that of the perspective rule – looking at this work would not see the difference between the real and the painted structure.

In particular, Pozzo's procedure is based on the projective rule of the '*reticulum*' invented by Leonbattista Alberti and developed by Albrecht Dürer, which allowed the correspondence between the vision of an object, projected on a vertical multi-squared plane from a specific point of view (eye), and its representation on a horizontal plane – that of the artist's table – containing the same geometrical *reticulum*.

The "Reverse Quadratura" procedure

The method we are developing is based on a similar procedure, but is applied in a reverse way. In this case, in fact, the finality of the research is to build the complex surface starting from some planar photographic images. It concerns a pre-process of Image Based Modeling, which was developed by Paul Debevec (Debevec 1996; Debevec, Taylor, Malik, 1996). Debevec algorithm is used in a very direct way in order to reconstruct a simplified geometry, based on planar surfaces, since in the preliminary step of calibration it is necessary to identify some main points

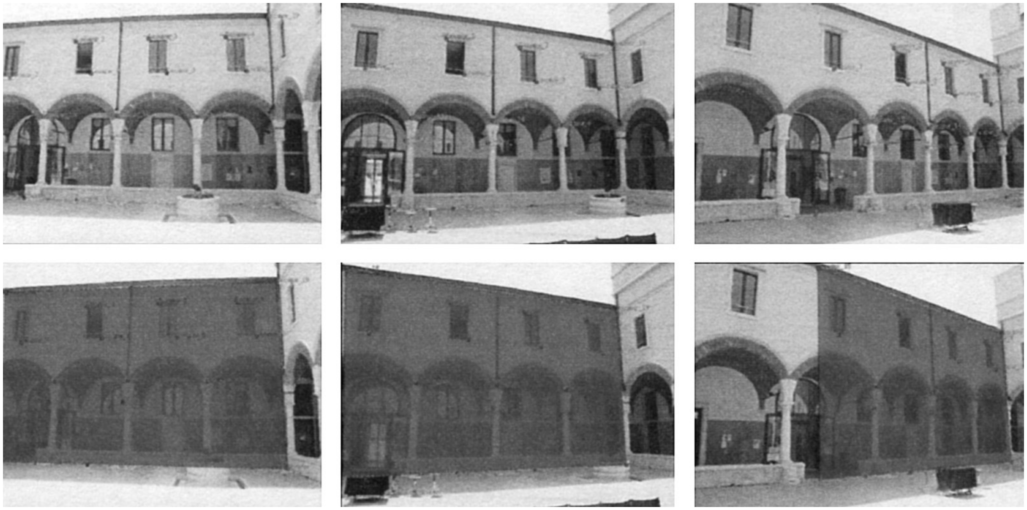
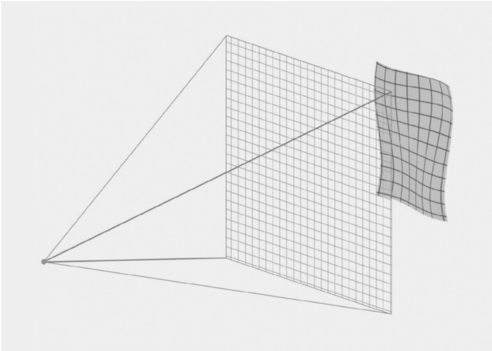


Figure 2
The application of the algorithm of Image-Based Modeling to a surface identified with control points

Figure 3
The projection of a grid on a curved surface



on photographic images to be calibrated in order to generate the texture mapped model of the scene. The problem of identifying the points is resolved by looking for them at particular intersections on the surface itself, as between two types of materials, or as small holes in a wall, or following the profile of a figure. In this way, you can use two or more photographs and identify the same points on them, in order to have a 3D specification of every single point on the flat image.

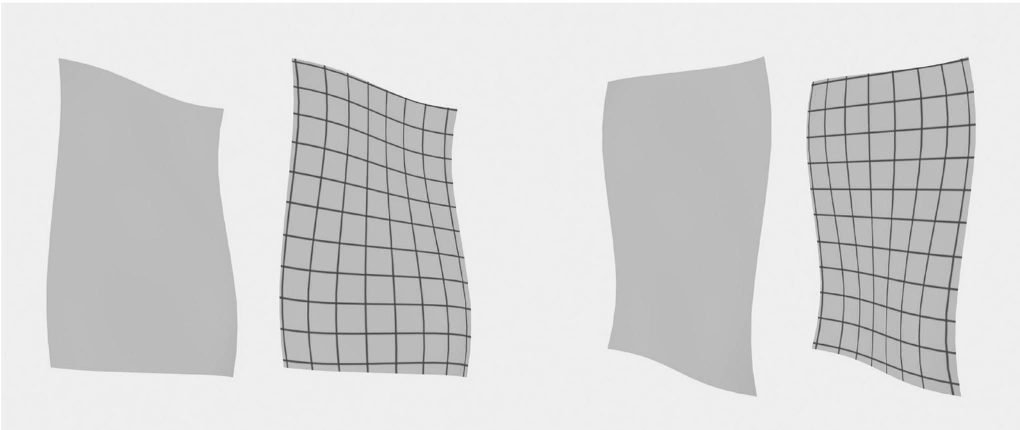
Therefore it is possible, as we know, to construct the three-dimensional element using graphic primitives integrated to the Image-Based Modeling software. But there are relevant difficulties when you have to find some specific points on a surface that does not have any of the particular details of identification before mentioned. In same cases one can put some target on the surface, in order to have some references for the subsequent calibration. But if the surface is difficult to reach – due to the distance from the viewer – one has no control points for the modeling operations.

The use of the "Reverse Quadratura" helps us to find a solution for those kinds of complex surfaces that do not have control points, because their surface colour is uniform or has no texture.

In fact we can project on the surface a grid – similar to the one of Andrea Pozzo – and subsequently we can take some pictures of it, changing the point of view according to the instruction of calibration.

The grid can give us some intersection points that would enable us to define the geometrical elements of the surface in order to calibrate together some different photographs. The perspective rules guarantee the correctness of the operation – every single photograph as we know is a perspective – and we can easily go over the step of a uniform colored surface. In order to have a very detailed textured surface, it is necessary to take two photographs from the same point of view, the first one with the grid projected on the surface, and the second one

Figure 4
The double images taken from two different points of view



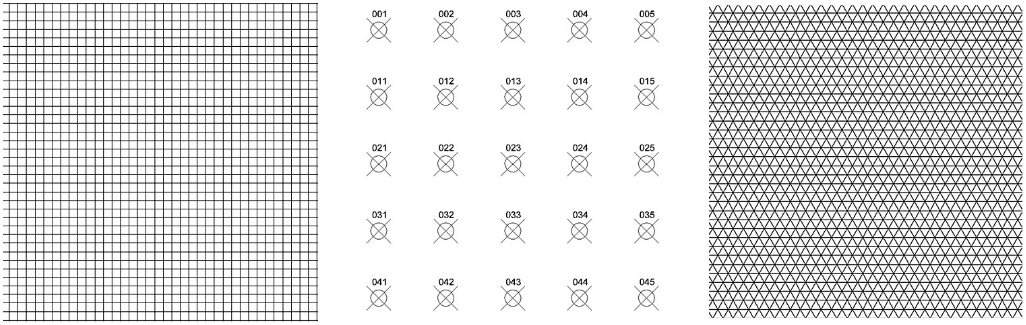


Figure 5
Different typologies of grids

without it, in order to switch the second with the first one after the operation of calibration. It is necessary to fix the camera on a tripod, without changing the position of the camera, to avoid any problems of calibration of the final texturing of the model.

As the main idea of this technique is based on a codified principle of projection, the problems of application of this method for this specific aim could have some difficulties of functionality.

Some technological problems concerning the quality of identification

One of the principal problems can be raised by the typology of the projector. In this case we have used a traditional electronic equipment: slide projector and digital one. In the first case we have used some slides with some kind of different grids; in the second case we have used a projector connected directly to a computer. The second was surely the most flexible way, because it gave the possibility of defining the type of grid and the quality of it, in relation to the form and dimension of the object we intend to survey.

We have planned also to try the same procedure using the micro digital projectors that are presented in some recent meetings, such as the SID 2007 Conference held at Long Beach in California (http://www.sid.org/conf/sid2007/sid2007.html). The instrument, called Explay Oio, enables the user to project with a laser-based diffractive optical technology, in order to have a well defined image on the surface. This nanotechnology will be integrated on the mobile in the future and it is possible that it could change the way we use our main communication systems, such as the computer display or TV.

In our case, it is important that the user can control the dimension of every single line of the grid, in order to have a precise base for starting the work, and not less than two projected-pixels.

Another element that can determine the quality of the procedure can be the typology of the grid. In fact the grid could be squared, triangular, pentagonal, hexagonal, depending on the object we are analyzing. If we want to have a strict correspondence between the grid and the graphic primitives, the best grid is the triangular one. But we have tried to use also single-point grids, colored points, numbered points, having obtained different results depending on the complexity of the form.

A further aspect to consider is the inclination of the grid in reference to the surface. The best results we have obtained are those that have considered the principal distance – from the point of view to the vanishing plane – equal to the normal line to the surface. If this rule is not applied, one will have some distortions of the grid that could generate some inaccuracies of the model itself (in this case you have a kind of anamorphosis).

In fig. 6 we have described, as a simulation, the procedure of calibration applied to a generic double

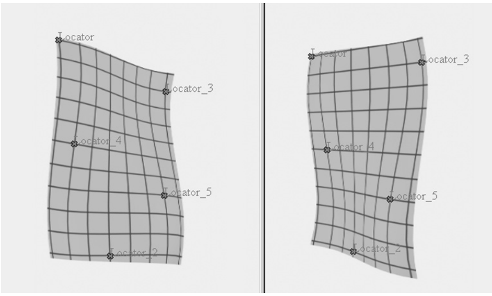


Figure 6
The procedure of calibration applied to a generic double curve surface

curve geometry, starting from the projected phase to the modeling one.

We have tested the method by applying it to some architectural elements and we will apply it to small design objects in order to understand the critical aspects of the procedure.

Using RQS for architectural elements

Some tests were made on architectural elements, such as a Doric capital. Working on it we have found some problems owing to the complexity of the superposition of every single component: abacus, echinus etc. It was necessary to work with a very small triangular grid, but, after some problems of identification of the points, we have decided to try a mixed grid, composed by a triangular grid and a coloured point grid superposed on the first one. In this case it was possible to recognize the discrete series of points in the phase of calibration.

Another element was a Doric column, which reconstruction was not so difficult, because of the single curve of the surface. In fact, it was possible to use a regular squared pattern of cm 2 x 2, to cover the whole column that has a diameter of cm 40.

Further developments of the method

As we have seen, this method is integrated to the well-known procedure of 3D modeling, starting from some images of the same object. The projected "quadratura" helps us to define better the skin of the element, reducing it to some small faces that can be easily reconstructed using standard planar primitives. But if we decide to use a grid made in such a way that the points could be recognizable (such as a series of single colored points), it could be possible to develop an algorithm – a sort of Optical Points Recognition, or OPR – that identifies all the same points on some different photographs automatically.

In this case the construction of the surface is made directly by the software and the user has to recognize only some points – at least three ones, as it happens in some software for 3D laser scanner that uses the method of optical triangulation, for detailed scanning – while the others are identified by the different chromatism of every point.

Conclusions

The results of this research allow us to introduce a new step in the procedure of Image-Based Modeling to survey single and double curved surfaces that do not have any reference points on it for calibrating and reconstructing the 3D model.

It could be used for the surveying of small design objects but also for bigger ones, such as architectural

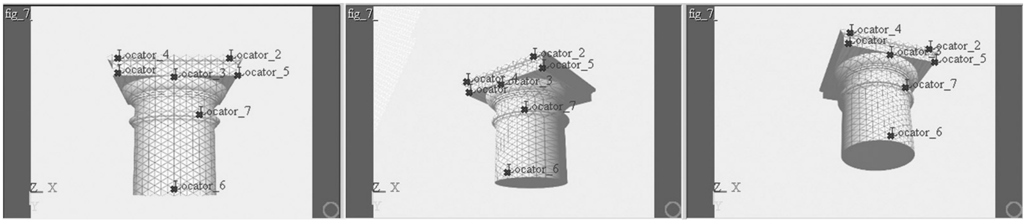


Figure 7
The application of RQS procedure a Doric capital

elements. It is important to underline that one of its main characteristics is that it is a non-invasive method that does not change and damage the surface of the component.

This research could have interesting applications in the field of education, because it could be a method to explain traditional techniques of representation – such as the perspective, but also the sophisticated procedure of the Quadraturism – and, at the same time, the evolution of the technology in the field of digital survey. Due to the low cost of these techniques – which needs only a digital camera, a video-projector (that every universitary school have) and a software of Image-Based Modeling – it could be used by every student for surveying small or big objects, translating them into a digital three-dimensional form.

If it could be possible to integrate this procedure to the use of a nano-projector and a software of Optical Points Recognition, the user could find in it a quick procedure to identify discrete points on a surface, without having the necessity to use a 3D laser scanner, for some surfaces.

References

Bosse, A.: (1648), Maniere Universelle di Mr Desargues pour pratiquer la perspective par petit-pied, comme le Geometral, Pierre Des-Hayes, Paris.

De Feo, V., Martinelli, V. (eds): (1996), Andrea Pozzo, Electa, Milano.

De Luca, L., Veron, P., Florenzano, M.: 2006, Reverse engineering of architectural buildings based on a hybrid modeling approach, Computers & Graphics, 30(2), pp. 160-176.

Debevec, P.E., Taylor, C.J., Malik, J.: 1996, Modeling and Rendering Architecture from Photographs: A Hybrid Geometry- and Image-Based Approach, in H. Rushmeier (ed), Proceedings of SIGGRAPH 96, Computer Graphics Proceedings, Annual Conference Series, Addison Wesley, pp. 11-20.

Debevec, P.E.: (1996), Modeling and Rendering Architecture from Photographs, Ph.D. Thesis, University of California, Berkeley.

Farneti, F., Lenzi, D., (eds): (2006), Realta e illusione nell'architettura dipinta : quadraturismo e grande decorazione nella pittura di eta barocca, Alinea, Firenze.

Filippi, E., (2002), L' arte della prospettiva. L'opera e l'insegnamento di Andrea Pozzo e Ferdinando Galli Bibiena in Piemonte, Olschi, Firenze.

Ikegami, H.: (1998), Sviluppo sommerso. Peculiarità della teoria prospettica di Andrea Pozzo, Clueb, Bologna.

Kemp, M.: (1990), The Science of Art. Optical themes in western art from Brunelleschi to Seurat, Yale University Press, New Haven and London.

Migliari, R. (ed): (1999), La costruzione dell'architettura illusoria, Gangemi, Roma.

Pozzo, A.: (1693-1700), Perspectiva Picturum et Architectorum, typis Joannis Jacobi Komarek Bohemi, Romae.

Sdegno, A.: (2005), From Architectural Intent to Physical model. Representing The Chiostro della Carità by Andrea Palladio with new technologies, in B. Martens, A. Brown, (eds), Computer Aided Architectural Design Futures 2005, Springer, Dordrecht, pp. 83-92.

Sdegno, A.: (2006), Between Design and Survey: Interpretative Problems in the Study of Drawings for Digital Modelling, MIA Journal, 1, 2006, pp. 39-50.