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# BOOK OF ABSTRACTS

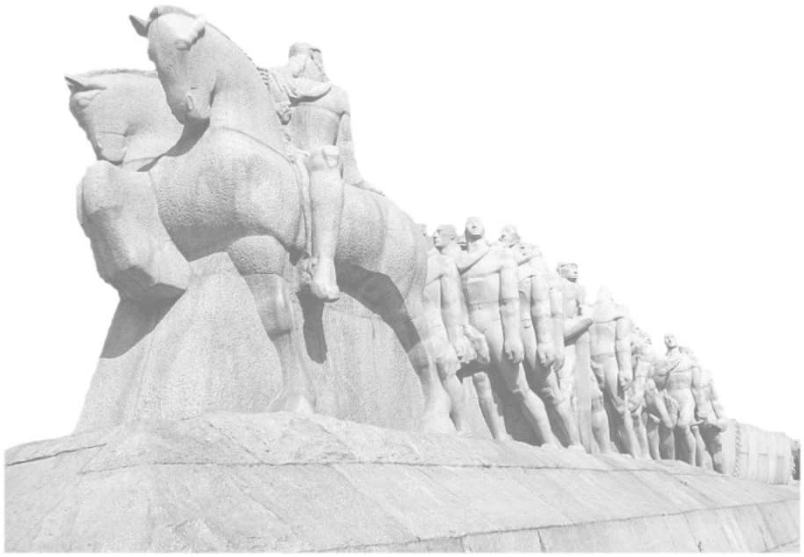
Universidade de São Paulo

ESCOLA POLITÉCNICA

ISGG

JSGS
Japan Society for Graphic Science

ABEG



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# Contents

**Part IV Graphics Education**

# INTERSECTING ARCHITECTURAL SURFACES BETWEEN GRAPHIC AND ANALYTIC REPRESENTATIONS

**Caterina CUMINO[1], Martino PAVIGNANO[2] and Ursula ZICH[2]**
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Since 2014, we have been dealing with Geometry as a common and shared language between Architecture and Mathematics. In this contribution we focus, from that point of view, on the relationship between the architectural object and its theoretical model by mean of analyzing its Geometry, also bearing in mind the context of first year Bachelor's in Architecture, with the wider goal of improving spatial thinking and visualization abilities. In fact, in architects' training when it comes to analyzing built shapes, there occurs the need to abstract their geometric essences from the real world. It is then important to provide students with instruments to derivate the theoretical object from its built counterpart. We have been focusing on particular architectural/ geometric realities such as compound vaults generated by intersecting surfaces and on the analysis of a variety of approaches for representing them: from the analytical one, which allows rigorous and unambiguous outcomes, to graphical ones, which are consequences of choices (of tools and constructive sequences) leading to only partially rigorous results. To analyze a groin vault with our students, we consider graphical representations of portions of intersecting cones, as outcome of a critical process of data discretization. We compare graphic solutions (obtained via descriptive geometry by CAAD-AutoCAD) and their different levels of approximation with a mathematical formalization (obtained via analytical geometry) and the use of a DGS (GeoGebra), reasoning about subjectivity and objectivity of the respective representations. We chose to use these tools because our students are at their very first year of academic studies, thus they are not comfortable with highly specialized software, with which they will be trained in more advanced courses. There are possible learning difficulties of epistemological nature related to the recognition of geometric objects in space, which involve understanding of concepts, symbols, procedures and different types of representations; even only from a mathematical point of view, indeed, a geometric object can be described by Cartesian equations, or by parametric equations, or even considering it as a set of points that verify the same property; then, students need adequate flexibility to switch from one register to another (in the sense of Duval). Thus we need them to experiment with simple tasks, avoiding possible issues with difficulties in spatial prefiguration capabilities they have might not already developed during their high schools studies. Students are provided with some testing and verification tool: on one side a DGS makes Mathematics accessible to experimentation; on the other side Monge himself, in his 1798 treatise *Géométrie descriptive*, suggested that one of the purposes of this science is to allow a graphic verification of objects' geometric properties and to suggest new previously unknown features. This remark reveals an aspect of Representation as an experimental science, where reasoning proceeds by adding other entities to the figure or by imagining operations that also have a physical model, such as plane sections. We propose analytical tools to critically verify students' geometric intuitions about built architecture, with the further possibility to highlight relationships between graphic representation sought and analytical properties of surfaces and resulting vaults. Such activities, in the spirit of visual thinking, allow them to visualize relations between surfaces in a more dynamic, manageable and intuitive way and to compare results obtained with a variety of architectural and mathematical tools, by means of implementing the use of the same theoretical concepts using the interdisciplinary language of Geometry.

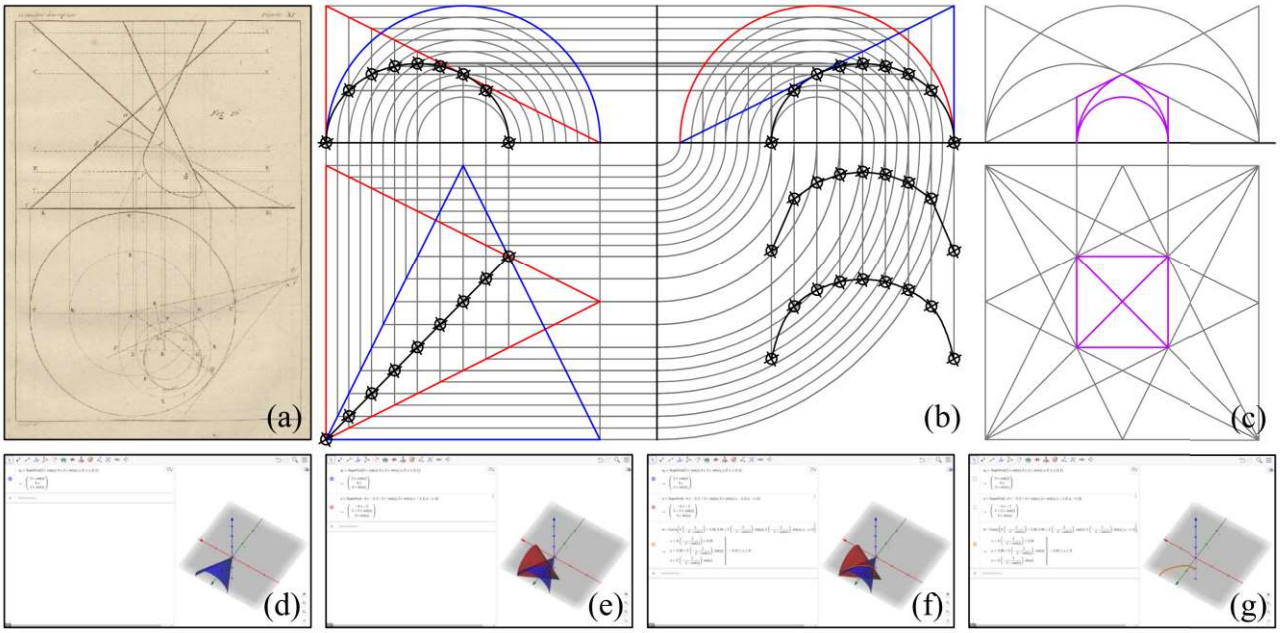


Figure 1. Different approaches to the relationship between cones. (a) Gaspard Monge, *Planche XI*; (b) CAAD orthographic projections of cones cut by a plane, the intersection curve is plotted graphically with the ellipse, polylines and splines tools to visually compare their different outcomes and approximation levels; (c) orthographic projections of a groin vault scheme generated by four cones; (d) - (g), views of related DGS model made by GeoGebra.

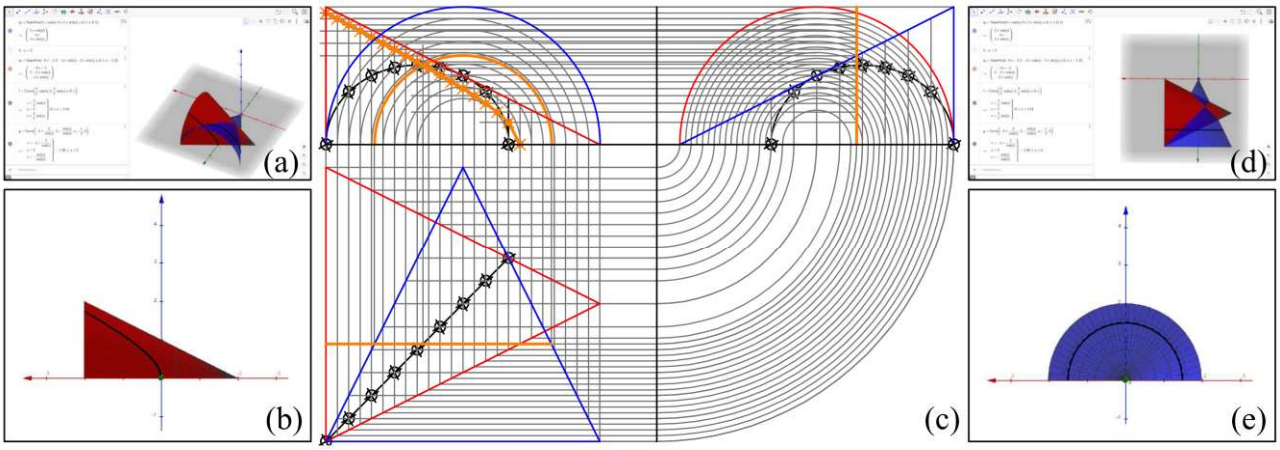


Figure 2. Intersection between two cones by cutting planes: focus on a step of the geometrical sequence. (a), (d) Views of DGS model made by GeoGebra; (b), (e) visualization of the same section on the surface of each cone; (c) orthographic projections of the graphic study of the intersection: in orange hyperbole and circumference defining the intersection point that is one of the possible points to describe the intersection line between the two surfaces.

Keywords: Intersecting Surfaces, Descriptive Geometry, DGS, CAAD, Visual Thinking, Theoretical Form.