Proportions vs dimensions: shedding a different light on the analysis of 3D datasets

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Heritage sciences (architectural heritage in particular)

Engineering sciences

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Survey protocols: acquisition and processing of raw 3D data
Photogrammetry, laser scanning, image-based modelling, etc.

Information visualisation: providing tools for reasoning on historical evidence, spotting trends and exceptions.

J.Y. Blaise, I. Dudek - Concentric Time: Enabling Context + Focus Visual Analysis of Architectural Changes
Focuses on depicting one particular item, with exhaustiveness, from the point of view of its geometrical features

Focuses on helping analysts to investigate a collection of items, to cross-examine data (beyond geometrical features)

J.Y. Blaise, I. Dudek - *Concentric Time: Enabling Context + Focus Visual Analysis of Architectural Changes*
Divergent lines of research?

The “observation” side

The “abstraction” side
Bedrock observations founding this experiment:

> a growing capacity of academics to produce large 3D datasets

> the emergence of low-cost survey techniques

> with that renewed capacity a methodological question is raised: what interpretation lines, what sensemaking opportunities does that move open?
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*This is basically a « proof of worthiness » experiment*

investigating the feasibility and added value of using a low-res, low-cost, “amateur” 3D point cloud in order to re-read pieces of architecture through simple *proportions, ratios* and *geometric relations*, in other words in order to *extract architectural features for comparisons*. 
• Terminological disambiguation

• On proportions (briefly)
  - The use of proportions in architecture over time
  - Proportions as prescriptions vs. proportions as an analytical tool

• The experiment – 29 rural, «non-elaborate» chapels
  - Acquisition and data extraction step: building on the MAP unit’s Aïoli experimental platform
  - Analysis step: some infovis-inspired solutions

• Future works: the SESAMES research programme
Terminological disambiguation: proportions (vs.?) ratios

In Vitruvius’ *ten books of architecture*

“The design of a temple depends on *symmetry*, the principles of which must be most carefully observed by the architect. They are **due to proportion**, in Greek ἀναλογία. Proportion is a **correspondence among the measures of the members of an entire work, and of the whole to a certain part selected as standard**.


Correspondence of the measures of an entire column, in relation with a « standard »: the module (bottom radius of the shaft)

E. Barberot
*Aide mémoire de l’architecte et du constructeur*
Ch. Béranger 1922
In Vitruvius’ *ten books of architecture*

“The design of a temple depends on **symmetry**, the principles of which must be most carefully observed by the architect. They are **due to proportion**, in Greek ἀναλογία. Proportion is a **correspondence among the measures of the members of an entire work, and of the whole to a certain part selected as standard.**


**intercolumniation in relation with a certain part, a « standard » : dimension D (module)**
In Vitruvius’ *ten books of architecture*

“The design of a temple depends on symmetry, the principles of which must be most carefully observed by the architect. They are due to proportion, in Greek ἀναλογία. Proportion is a correspondence among the measures of the members of an entire work, and of the whole to a certain part selected as standard.


In *Two Kinds of Proportion* by Matthew A Cohen

Introduction to “Objects of Belief: Proportional Systems in the History of Architecture”

Special collection of Architectural Histories, the EAHN (European Architectural History Network) international, blind peer-reviewed scholarly journal.

https://journal.eahn.org/articles/10.5334/ah.bv/ [last visited 08/04/2019]

Proportion can refer to ratios, or it can refer to architectural beauty. In this introduction to the papers that follow, Matthew A. Cohen proposes a simple clarification of this ambiguity as a framework for continued discussion of this subject: that whenever scholars use the word proportion, they specify whether they intend ‘proportion-as-ratio’ or ‘proportion-as-beauty’.
Terminological disambiguation: proportions vs. ratios

What will be intended in what follows intend is ‘proportion-as-ratio’

Summary of the San Lorenzo [Basilica San Lorenzo in Florence, 1424 > Filippo Brunelleschi ]

nave arcade bay proportional system
(spread between two drawings for clarity).

Introduction: Two Kinds of Proportion.
DOI: http://doi.org/10.5334/ah bv
On proportions: use over time

A (very) quick overview of when they mattered

Rome: Vitruvius

m/2

m

m (module)
Romanesque period: simple ratios

L’église cistercienne “ad quadratum”, dessinée par Villard de Honnecourt (XIIIe siècle), est régulée par des proportions musicales. Son plan est contenu dans un rectangle qui est un triple double carré (3/2), correspondant à la quinte. Son chœur (4/5) représente la quarte ; chaque bras de transept (4/2) est associé à l’octave, ainsi que le transept entier (8/4). Le croisement de la nef et du transept est un carré (4/4), symbole de l’unité. La nef enfin évoque la tierce (5/4).

T. Hatot
*Bâtisseurs au Moyen-Age. L’instant Durable* 1999
Renaissance period: Brunelleschi’s *Cappella dei Pazzi*
Up to modernist architecture

Le Corbusier’s *Villa Stein*

*Le Corbusier et la méditerranée*
Editions Parenthèses / Musées de Marseille 1987
On proportions: prescriptions vs. analytical tool

Proportions as quantitative relations to be applied by builders,

Proportions as a prescription

Le Corbusier’s Modulor
On proportions: prescriptions vs. analytical tool

Re-reading, analysing choices made by builders,

Proportions as an analytical tool

Ratios are here used in retrospect, as a tool in analysing Brunelleschi's design

G. Fanelli Brunelleschi
On proportions: prescriptions vs. **analytical tool**

Re-reading, analysing choices made by builders,

Proportions as an **analytical tool**

These 3 triangular figures are used by Viollet Le Duc to back up his theory, or observations, on one specific edifice.

E. Viollet Le Duc
*Entretiens sur l’Architecture*
Éditions Pierre Mardaga 1977 (ed.orig 1863)
On proportions: prescriptions vs. analytical tool

Re-reading, analysing choices made by builders,

Proportions as an analytical tool

But such triangular figures can also be used to question the homogeneity (or heterogeneity) of a set of comparable edifices.

E. Viollet Le Duc
Coup de la nef de la cathédrale d’Alby.
But such triangular figures can also be used to question the homogeneity (or heterogeneity) of a set of comparable edifices.
Reims 1211
Chartres 1194
Strasbourg 1190
Paris 1163
Soissons 1176
...
Gains in height, relative stability in width

Regularly distributed thresholds in height (on this specific subset)

Non-homothetical variations (crossing lines)

A triangular figure that helps re-reading a whole collection.
Correlation with period of construction

On this subset, a tendency to build higher naves, but that does NOT sum up what can be observed: the « lowest » nave is a « recent » one.

Analysing, through visual means, ratios, proportions, figures, does not necessarily mean coming to an assertive conclusion, but rather working on comparisons, providing food for thinking.
> proportions can be an effective, rewarding lecture grid when observing « elaborate » pieces of architecture.

But can they be of any benefit when observing small-scale vernacular architecture? What exactly is there to uncover in that particular context?

*Santa Maria Novella (Alberti, Florence 1458 >)
Analysis by R.Wittkower
« Architectural principles in the age of Humanism »
Academy Editions 1998 (first ed. 1949)
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That is precisely an issue that the emergence of lightweight, low-cost survey techniques allows us to address.

No claim that this experiment did help uncover significant trends in terms of « ways of building », but a confirmation that there is a line of research within reach.
Context: a short-term research programme called « Territographie » questioning the applicability and scientific added-value of the citizen science paradigm in the documentation and analysis of minor heritage items.

< territographie.map.cnrs.fr >

A concern for different collections

As part of the initiative, the idea that a low cost protocol for the acquisition of raw 3D data, including through citizen contributions, could be tried out.
The experiment – 29 rural, « non-elaborate » chapels

Context: a short-term research programme called « Territographie » questioning the applicability and scientific added-value of the *citizen science* paradigm in the documentation and analysis of minor heritage items.

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> A baseline choice: photographic captors,
Acquisition and data extraction step: builds on the Aïoli collaborative platform

> L. De Luca, A. Manuel, A. Alaoui

www.aioli.cloud

A reality-based 3D “annotation” platform (collaborative annotation of 3D regions in point clouds).

The application generates a 3D point cloud from photographs, which can then be annotated.

*Based on two technological developments:*

> photogrammetry techniques, (computing of a 3D model by correlation of images)
> massive processing and sharing gathered data through the cloud.
3D “regions” (subsets of the point cloud) can be isolated and annotated in the 3D space
And the result reprojected on each photograph used to compute the point cloud3D
In this experiment we make use of another feature: retrieving “relative dimensions”, i.e. quantities that will be saved as ratios (and not as metric information).
Input: photographs (multi-captors)

Output: raw 3D point clouds

Output: ratios (transferred into a visual language)

The overall protocol

Processing pipeline:
- feature detection
- Calibration and orientation
- Dense matching

Output: ratios (transferred into a visual language)
The ratios selected

> Proportions of Facade

H1/W1
H2/W1
The ratios selected

> Proportions of Facade

\[ \frac{H1}{W1} \]
\[ \frac{H2}{W1} \]

> Facade vs. bell tower

\[ \frac{BW}{W1} \text{ (widths)} \]
\[ \frac{BH}{H2} \text{ (heights)} \]
The ratios selected

> Proportions of Facade

- H1/W1
- H2/W1

> Facade vs. bell tower

- BW/W1 (widths)
- BH/H2 (heights)

> Surface of openings vs. of Facade

- S1/S2
- S3/S2
Visualisation of ratios, edifice per edifice

- Proportions of Facade
- Facade vs. bell tower
- Surface of openings
Visualisation of ratios, edifice per edifice

> Proportions of Facade

width set as fixed unit

$b = x\% (a)$

$c = y\% (a)$

Hauteurs par rapport à la largeur de la façade: 117 %, 129 %
Visualisation of ratios, edifice per edifice

> Proportions of Facade

width set as fixed unit

c = 100% (a)

Hauteurs par rapport à la largeur de la façade: 117%, 129%
Visualisation of ratios, edifice per edifice

> Proportions of Facade
Visualisation of ratios, edifice per edifice

> Proportions of Facade

trends, similarities
Visualisation of ratios, edifice per edifice

> Facade vs. bell tower

100 % of the height of the facade

100 % of the width of the facade

Largeur, Hauteur du clocher par rapport à celles de la façade: 41 %, 22 %
Visualisation of ratios, edifice per edifice

> Facade vs. bell tower

y % of the height of the facade

x % of the width of the facade

Largeur, Hauteur du clocher par rapport à celles de la façade: 41 %, 22 %
Visualisation of ratios, edifice per edifice

> Facade vs. bell tower

Does not show the « shape » of the bell tower but its relation to the facade

Square: homothetic relation

Largeur, Hauteur du clocher par rapport à celles de la façade : 41 %. 22 %
Visualisation of ratios, edifice per edifice

> Facade vs. bell tower

Largeur, Hauteur du clocher par rapport à celles de la façade : 41%, 22%
Visualisation of ratios, edifice per edifice

> Facade vs. bell tower

exception

trends, similarities
Visualisation of ratios, edifice per edifice

$c^2$

*Surface of the « windows »*

$b^2$

*Surface of the « door »*

$a^2$

*Surface of the facade*

> openings

ouvertures: 0.5%

Porte: 8%
Visualisation of ratios, edifice per edifice

> openings

ouvertures: 0.5%

Porte: 8%
Visualisation of ratios, edifice per edifice

Visual solutions designed on purpose.

lays the information down, helps identifying exceptions and trends, similarities.

Patterns corresponding to the collection as a whole require other visual solutions.
Visualisation of ratios, collection reading

The parallel coordinates formalism

Reading of clusters
A distribution plot on bell tower proportions in comparison to façade proportions
Visualisation of ratios, collection reading

A distribution plot on bell tower proportions in comparison to façade proportions

This diagonal: homothetic relations (A most unusual situation)
Summary and perspectives

What we have done up has more to do with *delineating a playground* than with actually uncovering significant trends in terms of « ways of building »,

The experiment acts as a confirmation that there is a challenge now within reach: experimenting low-cost, lightweight survey techniques that can help analysts rethink the way they get hold of, and cross-examine, 3D data seen as hints about ways of building.

Of course the whole approach does NOT require the computing of a 3D point cloud – only, having it is a means to go back to the source, and somehow make of the 3D point cloud a repurposeable content.
Next step: the SESAMES research programme

A multimodal, low-cost survey protocol designed for the extraction of significant architectural features

Photogrammetric protocol from Panoramic images

- feature detection
- Calibration and orientation
- Dense matching

*Point to point direct measurement (DXF)*
Summary and perspectives

> Testing the approach on interiors