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

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Abstract: In the last decades, many methods (e.g., digital photogrammetry, laser scanning, dense image matching, etc.) have been introduced that result in a renewed capacity of academics to produce large 3D datasets. Naturally research objectives, technological suites, levels of accuracy expected, or scales of objects under scrutiny strongly vary - hence a wide range of “outputs” corresponding to various data interpretation strategies.

But with that renewed capacity a methodological question emerges: does the “massive amount” of 3D data a survey results in really corresponds to the analytical need? Ultimately, is the added-value of “going massive” undeniable?

We argue that this capacity to “go massive” can also open opportunities to investigate new analytical filters. We base on the idea that more 3D data does not imply abandoning our capacity to synthesize - low cost survey suites can in fact give us a chance to revisit fundamental metrics in the history of architecture: proportions, rather than exhaustive dimensioning.

We investigate how a low-res 3D point cloud can be re-read with the aim of identifying simple ratios and geometric relations, in other words of extracting meaningful architectural features, in the context of a citizen-science initiative.

The paper underlines the cognitive potential of reading proportions in the history of architecture (both at design and analysis levels) and focuses on an experimentation conducted on a set of “comparable” edifices. The approach exemplifies a shift from a one-shot, exhaustive documentation of

one edifice to a workflow dedicated at decoding and visualising relations inside a collection.

Heritage sciences are today strongly impacted by a “thirst for digitization”: in that context 3D data acquisition and processing technologies are gradually paving their way into the work practices of both academics and collection holders.

Naturally research objectives, technological suites, levels of geometric accuracy required, scales of objects under scrutiny, types of information targeted do strongly vary. Hence a set of operations (both technical and cognitive) that lead from the data acquisition step itself to a wide range of “outputs” or “results” corresponding to various levels and strategies of interpretation of the raw 3D data: reconstruction of 3D models and H-BIM applications (Banfi et al. 2018), 3D printing (Karnapke & Baker 2018), assistance to diagnosis in conservation (Salonia et al. 2007), structural analysis (Kalisperakis et al. 2015), augmented reality applications (Cardoso & Belo 2018), archaeological site spatial documentation (Gonizzi Barsanti, Remondino & Visintini 2013), *etc.*
The amount, diversity, medley and sometimes complexity (in terms of procedural knowledge concerned) of these operations is definitely a challenging aspect of the heritage science community’s move towards “more” 3D data acquisition and processing. In particular, it jeopardises the community’s capacity to formalise and preserve research processes on the long term, and therefore to ensure a *reproducibility* of these processes – a key methodological (and sustainability) issue raised in (Dudek & Blaise 2017).

In this paper we address yet another challenging aspect of the above move, a challenge that emerges at the moment of shift between:

a) the 3D surveying activity itself, resulting in massive “raw” 3D datasets (*e.g.* millions of points acquired through technologies ranging from image-based solutions to laser-based 3D scanning platforms),

b) the data processing chains that build on these 3D datasets, but that introduce various technological or cognitive biases, and in turn raise new challenges in terms of interpretation of the 3D point cloud - scene analysis or automatic semantic interpretation as shown in (Weinmann et al 2015) for instance.

This methodological challenge can be summed up by a series of open questions, as follows: does “massive” 3D data contemporary survey techniques foster really correspond to any analytical need? Which percentage of the information is indeed relevant? When processing the data in order to increase its usability, for instance by filtering it or through meshing operations, to which extent is there a loss in terms of quality? At the end of the day, is the added-value of “going massive” undeniable at analysis time? Rephrasing words written back in 2008, in the context of information sciences: *turn the information overload into an opportunity* (Keim et al. 2008), we argue that the Heritage Science community is today facing the issue of *turning the data overload into an opportunity for information extraction*.

Given the renewed capacity of academics and cultural actors to produce large 3D datasets, are there analytical filters that are becoming within reach for investigators? Are we in a position to re-analyse heritage items and in particular to foster comparative analyses?

This contribution presents a research initiative that can be seen as a methodological answer to the above questions, an answer on general terms, on a theoretical basis, but through a real-case exemplification of how the analysis of massive 3D raw data (point clouds) may benefit from a shift in terms of methods (inspired by the information sciences community) and open up on new analytical filters.

What we present is basically an “*is it worth?”* experiment. We investigate the feasibility and added value of using a low-resolution, low-cost, “amateur” 3D point cloud to reread pieces of architecture through simple proportions, ratios and geometric relations, and ultimately to extract architectural features for comparisons. The approach is meant to feed a comparative, visual and abstract analysis of proportion ratios on a set of comparable, small-scale heritage artefacts (rural chapels distributed in the Southern Alps).

Accordingly the paper is structured as follows: section 2 very briefly introduces the two sets of methods and practices that are concerned: namely 3D surveying and information visualisation to define their overlapping with the research we are reporting on.

Section 3 briefly presents the case study (28 rural chapels), and its context of emergence: a programme targeting a corpus of poorly documented or undocumented rural chapels for which we investigated how “amateurs” could contribute to a potentially collaborative photogrammetric surveying process.

In section 4 we disambiguate the terms "ratios" and "proportions" frequently used in the field of architecture (and not only in the context of heritage assets), terms definitely polysemous in that area. We also underline through a set of examples how these "metrics" have been at the heart of the architectural discourse over time, both as design guidelines and as analytical tools.

Section 5 focuses on the 3D data acquisition protocol used and details the pipeline (data acquisition and processing) on which the experiment bases. We position it with regard to alternative solutions and to the context that lead to our choice. In Section 6 we introduce the visual solutions designed to support analysts in their effort to spot patterns and exceptions across the sets of items concerned. Finally, section 7 sums up what we consider as the potential benefits of such a research path, and lists the limitations of the experiment reported.

Section 2. An intersection of methods and practices

The activity of our research unit can be seen as taking inspiration (instruments, formalisms, models) from information sciences and engineering sciences to back up analysts working on heritage items. But when looking closer we have in fact been conducting research works on heritage assets (architectural heritage in particular) from two different angles:

- engineering sciences, with a focus on the acquisition of raw 3D data (photogrammetry, laser scanning, image-based modelling, *etc.*) and geometric data processing,
- information sciences, with a focus on historical data quality assessment, heterogeneous data correlation, temporal aspects, and integration of legacies from the information visualisation (InfoVis) community.

Naturally one could think the overlapping is natural: results of a survey protocol (typically a 3D point cloud, or at least a list of spatial features) can be seen as data, and it *is* data. But it has nothing to do with the data one handles when harvesting scarce pieces of information, barely hints sometimes, about what an edifice was "a long time ago, before it became what we can survey today". Hence we developed methods and approaches that widely differ.

Said differently, on the one hand we tend to focus on depicting one particular item's geometrical features by a consistent ***observation*** method. On the other hand, we tend to focus on helping analysts to spot trends and exceptions in a collection of items, to cross-examine data (beyond geometrical features), to support ***interpretation*** and ***abstraction*** strategies.

Even when working on "3D modeling" aspects our experiences have rarely pulled together competences in 3D acquisition protocols and capabilities in the interpretation steps. For instance in the *Tactichronie* device presented at CAA 2012 (Blaise & Dudek 2013), in which we did produce tangible reconstructions of various evolutions of Krakow's market square. The input in that study was mainly documentary, acquisition protocols counted for almost nothing simply because there is little left to observe due to 19th-century destructions.

In a way, this particular experiment can be seen as an attempt to bridge the gap between those lines of research. Naturally relations between the technologists/observers and the analysts/interpreters are today necessary and potentially fruitful in many areas of cultural research, as shown for instance in [Bogacz & al. 2018]. Our contribution implements a pragmatic vision that although a 3D point cloud can be seen as "too much data" when wanting to focus on proportions in architecture, it can still help.

Section 3. The research context

This research was conducted in the context of 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 (Blaise, Dudek & Saygi 2019). The programme endorses M.F. Goodchild's vision of "citizen as sensors" (Goodchild, 2007), seen as one of the few practical solutions for local actors as well as for scientists to harvest pieces of information about small-scale, "non-prestigious" architectural artefacts (left aside from large official heritage programs) and to gain a better understanding of their making and evolution. In its first stage, the programme has focused on identifying and documenting those artefacts (1400 rural chapels distributed in the south-east of France), using highly heterogeneous citizen-birthed information sets, with their load of uncertainties and interpretation difficulties.

Then the effort has been put on circumscribing the obstacles one has to foresee if wanting to derive from such information sets spatial, temporal and thematic knowledge. Our concern was, in particular, analysing information providers' profiles and practices in relation to the datasets they are producing.

As part of that initiative, and given the corpus considered (no chance to send professionals to survey these edifices), we came up with the idea that a low-cost protocol for the acquisition of raw 3D data, including through citizen contributions, should be tried out. We selected randomly 28 edifices (Fig1) and asked people without any background knowledge about photogrammetry to perform the photographic survey using various captors. It has to be said clearly that our goal was basically to check out if that idea was worth developing. To this day, we have not launched a full-scale crowdsourcing-like initiative to document the whole collection of edifices.

Fig 1: Left, spatial coverage of the *Territographie* research programme. Right, edifices considered in the experiment.

Section 4. About proportions: a terminological disambiguation

The term proportion is defined in the Roman architect Vitrivius' *De architectura* (seemingly the oldest treaty of architecture) as follows (hellenicaworld 2019):

"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".

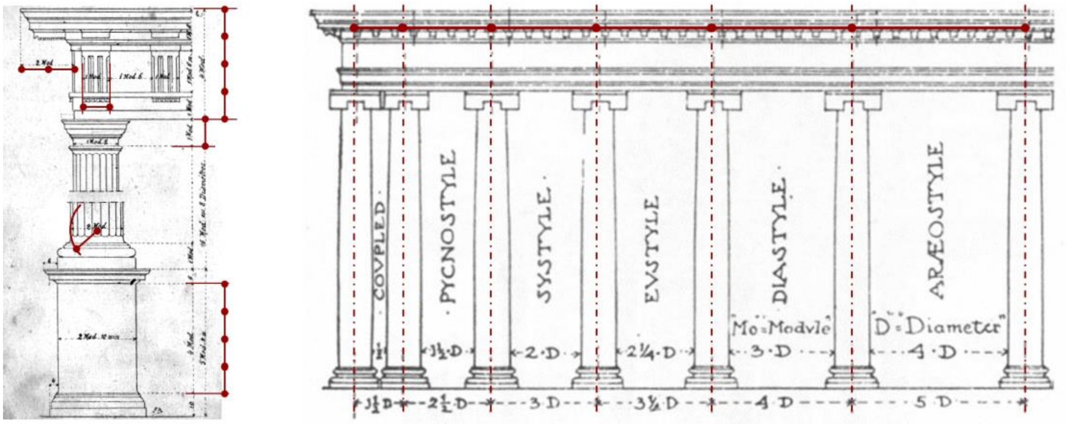

Fig 2 A classic example of Vitruvius' vision of proportion *as a correspondence*: use of the module (bottom radius of the shaft). Left, the module used to dimension components whole column (redrawn over graphics proposed in E. Barberot's *Aide mémoire de l'architecte et du constructeur* published in 1922). Right, the module used to control the position of columns – alternative intercolumniations (redrawn over graphics proposed in C.R Harris' *Illustrated dictionary of historic architecture* published in 1983).

The above figure (Fig 2) shows two very classic examples of such correspondences: a correspondence of the measures of a column, in relation with a « standard »: the module, used to calibrate the whole column and intercolumniations defined in relation with that same « standard » - a standard that is also used to set relations between distant objects. But the term proportion has been widely used since then in another sense: in the architectural discourse (and even more in the everyday language) proportion is often used as a sort-of synonym of "beauty". In Matthew A Cohen's Introduction to "*Objects of Belief: Proportional Systems in the History of Architecture*" (Cohen 2014) the author shows that proportion can refer to ratios, or it can refer to architectural beauty. 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*'. What will be intended in what follows is clearly '*proportion-as-ratio*' as reached through quantities called ratios, hence in the primal sense of the word as established by Vitruvius.

This notion of '*proportion-as-ratio*' has been widely used over time by builders, architects and writers commenting about architecture in their effort to select or to depict design principles. Accordingly it should be considered as a means to analyse the *dimensions* chosen in the construction of edifices.

It is as mentioned present since the Roman period, in Vitruvius' writings, but it is also at the heart of the builder's *savoir-faire* during the Romanesque period, as demonstrated by T. Hatot, who shows that simple ratios (3/2, 4/3; 4/2 etc.) are of systematic use in the construction process of religious artefacts at that time (Hatot, 1999). Whether these simple ratios were indeed chosen for their symbolic power, for their relation to "musical proportions" (fourth, fifth, octave, *etc.*), or whether they are the simple, natural consequence of a monotonic constructive system can be debated, but such a debate would go far beyond the scope of this paper. The Renaissance period, with its load of references to Classic Architecture, and the re-discovery of Vitruvius' text is probably the golden age of architectural theories (and practices) building on strict obedience to a "conceptual" system of proportions. In a reference work with the title "*Architectural principles in the age of humanism*" R. Wittkower (1949) underlines how ideas and symbolisms supposedly inherited from Pythagoras or Plato impact the reasoning of thinkers and builders of the time, from De l'Orme's *divine proportion* to Serlio's *right* construction of the door of a church (a square, its two diagonals and an isosceles triangle). Closer to today, with modernist architecture, proportion still remains a major lecture grid for architects: a prominent example is definitely Le Corbusier's works, for instance the 1-2-1-2 system he implements for Villa Stein (not to quote his famous *Modulor*, a whole system of proportions). Today, theories tend to pave the way to yet another "system of dimensions": this of normalised industrial products, yet another set of rules that builders cope with.

The use of *symbolic and perfect numbers* in the design of architecture is often commented on by architectural historians, as demonstrated by Elizabeth den Hartog on Gothic architecture (Den Hartog 2014). Alberti uses proportions and simple ratios not only in his architectural theoretical discourse, but as a builder, as pointed out by R. Wittkower (Wittkower 1949). Le Corbusier's *Modulor* is not a lecture grid superimposed on the architect's opera *a posteriori*: it is the standard measure the architect uses in dimensioning spaces (Le Corbusier 1950). It is a self-imposed prescription concerning quantitative relations to be applied in the design phase.

These examples show that proportions play two different roles in the history of architecture: the role of prescriptions (rules the builder should follow) or the role of analytical tool (lecture grid the scholar or commenter will use to unveil the builder's intent, or the significance of its work).

Obviously, in the context of this research, we rather envision the role of proportions as an *a posteriori* analytical tool. We consider them as one of the means at hand to characterise an edifice and to allow for a comparative analysis of edifices. Such use of proportions is far from being new: E. Viollet Le Duc uses triangular figures to re-read and analyse proportions Gothic builders chose in the construction of cathedrals (Viollet-le-Duc 1978). In a recent paper, A.Tallon reinterprets that vision in an analysis, backed up by several laser scanning campaigns, of sections of gothic cathedrals on which he superimposes an equilateral triangle (Tallon 2014) (one of the many analytical grids he proposes). A large number of more "classic" examples of such a posteriori analyses can be found concerning the works of one architect - *e.g.* Brunelleschi's architecture (Fanelli 1980) - or the frame of mind of a time (Ottenheym 2011).

What can be said concerning our research is that it aims, just like A.Tallon's, at taking advantage of emergent 3D data acquisition and processing chains to ground classic analyses of proportions and hopefully, to re-question and widen them.

Three major particularities of our approach must, however, be quoted so as to position it more precisely with regards to the state-of-the-art:

- We have deliberately chosen a low-cost, low-resolution 3D data acquisition chain, as a consequence of the corpus we analyse (poorly documented, left aside from large funded heritage programmes).
- Since we are dealing with "non-erudite architecture" (works of local builders, practitioners above all, may they have been in contact with theoretical discourses or not) we have chosen to initiate the research on a set of straightforward proportions, not necessarily on a lecture grid that would match architectural theories. Hence we shall not look for predefined "figures" (the square, the equilateral

triangle, the 1-2-1-2 rhythm, *etc.*) but remain at a very pragmatic, non-directive level of interpretation.

- Our goal with this research is not actually demonstrating that architectural analyses using proportions as a lecture grid can benefit from new technologies – it is simply obvious and demonstrated by many contributions. Our focus is instead put on how to transfer the "proportions" information (numbers) into an abstract visual language, inspired by the information visualisation community, a language that would facilitate comparative analyses inside a collection of edifices.

Section 5.The 3D data acquisition protocol

The acquisition protocol builds on a collaborative photogrammetric platform that is being developed within our research unit, the *aïoli* platform (Manuel et al. 2018). The platform is defined as a "reality-based 3D annotation platform": it is intended at allowing users to annotate 3D regions inside point clouds though a collaborative, online platform using standards of the web. The application generates a 3D point cloud from photographs. 3D "regions" (subsets of the point cloud) can be isolated and annotated in the 3D space or on the photographs used to generate the point cloud. The result (a 3D region) can then be re-projected on each photograph used to compute the point cloud (Fig 3).

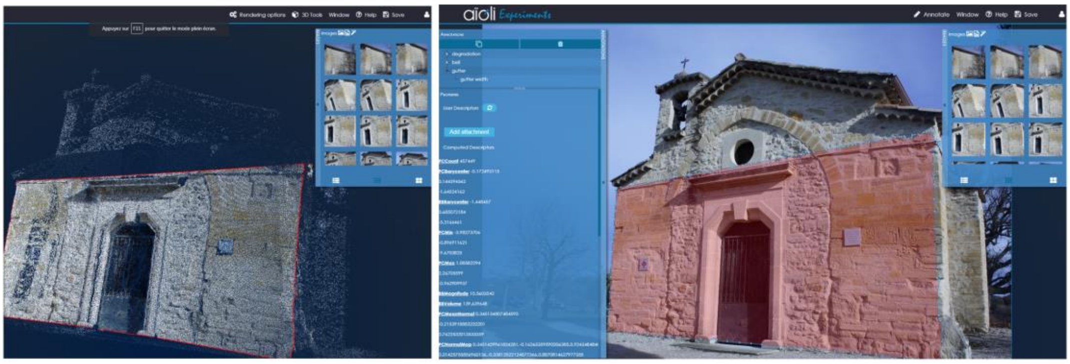

Fig 3 The *aïoli* platform online interface. Left, a rectangular 3D region has been isolated on the point cloud. Right, the region is re-projected on one of the photographs used to generate the point cloud.

It is based on two technological developments: photogrammetry techniques (computing of a 3D model by correlation of images) and massive processing and sharing gathered data through cloud computing solutions. The processing pipeline is a three-step pipeline: feature detection, calibration and orientation, dense matching, that is supposedly adapted to various photographic captors (from smartphones to professional cameras). This last aspect is one of the reasons why we decided on conducting our experiment using that platform. As mentioned in section 2 the context of this research is a citizen-science programme, hence a necessity for us to make sure that outputs produced by “amateur” photographic captors could be exploited.

In this experiment we do not build on the annotation service the platform offers, but make use of yet another service: retrieving “relative dimensions“, i.e. quantities that will be saved as ratios (and not as metric information). In other words, the 3D point cloud is not scaled, but used as raw data from which only ratios are retrieved.

The overall protocol combines the following steps: the input are amateur photographs, produced using a variety of photographic captors. The processing pipeline leads to two outputs: on the one hand raw 3D point clouds, on the other hand ratios, manually extracted from the raw 3D point clouds, saved as textual data. That data is then transferred into a visual language using a series of scripts that produce SVG (Scalable Vector Graphics) visualisations embedded inside HTML pages (Fig 4). The next section further details that last step.

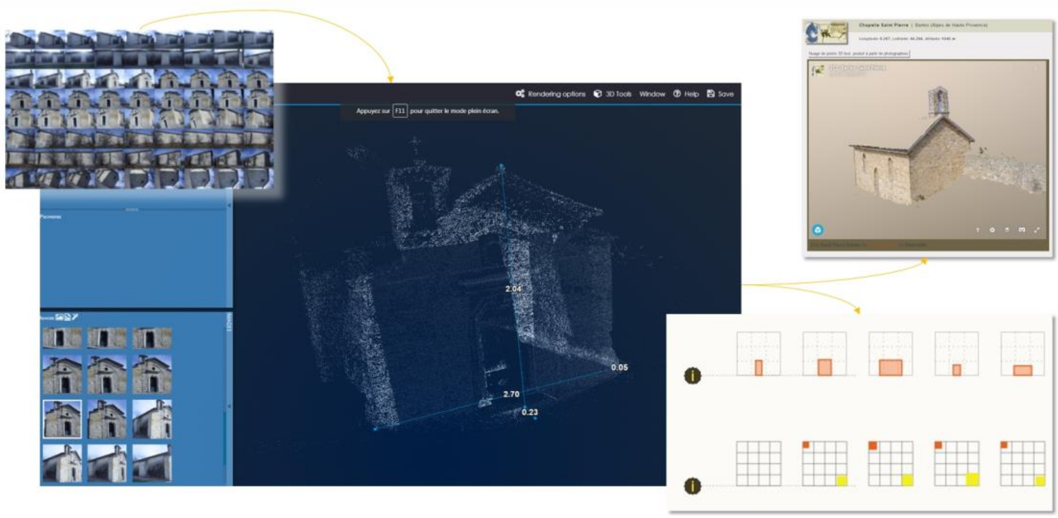

Fig 4 The overall protocol: amateur photographs are processed using the aioli photogrammetric processing pipeline, 3D point clouds are published as raw material, and in parallel proportions are manually extracted from the

raw 3D point clouds, saved as textual data, and transferred into an abstract visual language.

Naturally the data acquisition process could have been conducted using a variety of other technological solutions, typically using a commercial software suite such as for instance PhotoScan (now called Metashape), commonly used in architecture (Fangi et al. 2018) and archaeology (Kimball 2016). In addition, given the very small number of “proportions” we have selected for analysis, it could even have been conducted using a basic distance meter (and in our case, it would probably have been a faster solution). What can be said here is that our goal was to address the issue at a methodological level, in other words to investigate the added-value of the workflow in our specific research context (see section 2). In that sense we consider it was legitimate to experiment with workflow that does not imply a specific instrumentation on the information provider side.

Section 6. Visual analysis and collection reading

The ratios we selected for analysis are limited to components of the entrance facades (exteriors), and combine dimensions (*e.g.* height vs. width) and surfaces (*e.g.* surface of openings *vs.* overall surface of the façade). They are illustrated in Fig 5.

Three visual formalisms have been designed to facilitate an analysis of each individual edifice (visual “profile” of its features), a reading of trends and differences across the collection (comparison tasks), and a spotting of uncommon behaviours (contrasting cases). The three visual formalisms are combined into one graphics in which a column corresponds to an edifice, and lines are used to transfer values corresponding to each of the three ratios mentioned in Fig 5.

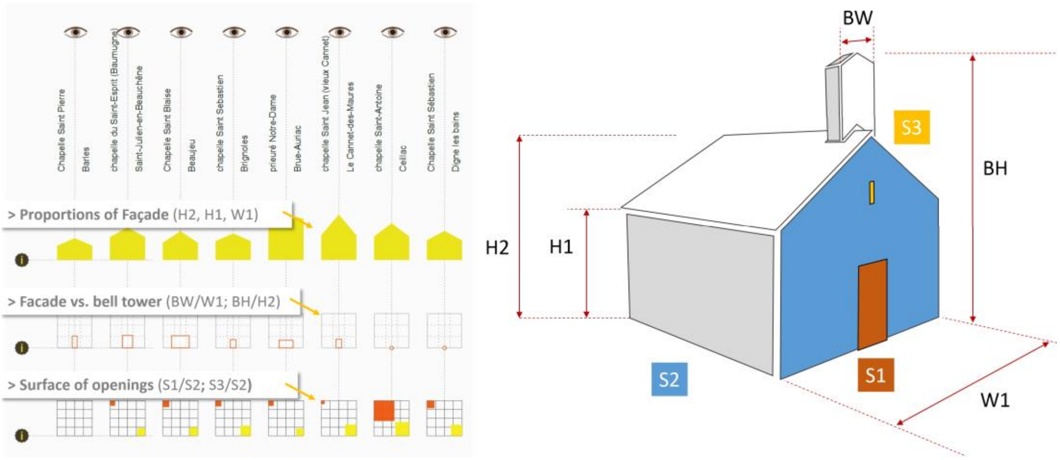

Fig 5 Left, the three visual formalisms designed to layout and compare the data collected on proportions of facades, proportion of facades in comparison to those of bell towers, surfaces of openings. Right, the actual dimensions used illustrated on a schematic figure.

The first line maps the information *proportions of the façade* (height/width ratio). The width of the edifice is set as a fixed unit and heights are shown in percentage of the width. This allows for a very fast and intuitive reading of the graphics, with for instance the verticality of some edifices, or the presence of relatively flat roofs, easy to spot. When examining the whole series of icons distributed horizontally, the analyst can uncover trends and similarities (patterns inside the collection) as well as exceptions (Fig 6).

Fig 6 Left, the visual formalism dedicated to the comparative analysis of proportions of facades (partial view). Note for instance patterns p1 and p2, and in contrast the four remaining edifices. Right, the making of the figure: **a** is a fixed unit, **b** corresponds to dimension H1 and c to dimension H2 as defined in Fig5, expressed in proportion to W1. An edifice with a width and

a height (ridge of the roof) having the same value would be inscribed inside a square.

The second line maps the information *façade vs. bell tower* (height/width ratios). In this visualisation we use a square, divided into nine equal parts, representing the overall surface of the façade (*i.e. 100%* of that surface). We then superimpose on this background square a rectangle that represents the bell tower's proportions in comparison to those of the façade, in width and height (fig 7). In other words the rectangle does not show the actual proportion of the bell tower, but a percentage expressing ratios in width and in height between the façade and the bell tower. If both have the same proportions, *i.e.* are in a homothetic relation, what will be drawn is a square inside the background square. Here again, trends and similarities are visible, as well as exceptions – although direct one to one comparisons are not obvious, a point discussed further below.

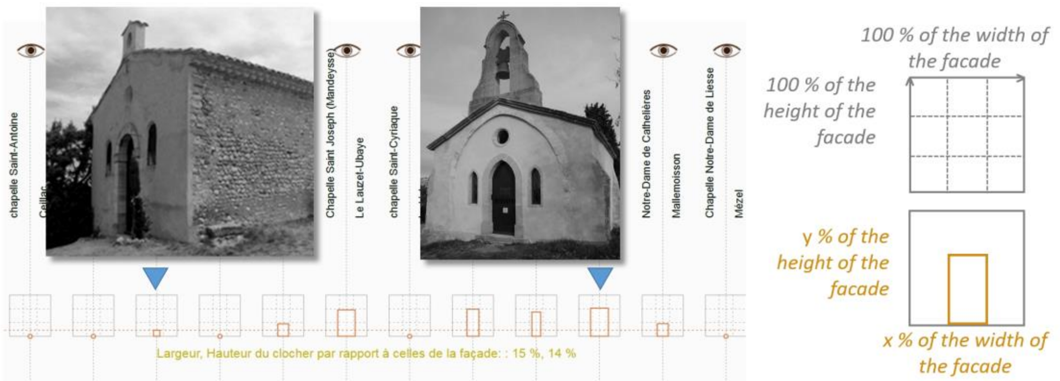

Fig 7 Left, the visual formalism dedicated to highlighting differences in proportions between the facade and the bell tower. Note for instance that in this partial view there is only homothetic relation (a square inside a square, same proportions for the façade and the bell tower): the edifice illustrated on the left image. The edifice depicted on the right image corresponds to yet another exceptional feature: a singularly large bell tower in comparison to the façade (as far as this collection is concerned, naturally). Right, the making of the figure: the grey background square represents the dimensions in height and width of the façade, the foreground rectangle proportions of the bell tower expressed in proportion to those of the facade.

The third line maps the information *surface of openings vs. overall surface of façade*. We use the same square as for the previous visualisation, divided this time in twelve equal parts, representing the overall surface of the façade (*i.e. 100%* of that surface). Over it are superimposed two other squares, a yellow one anchored in the bottom right corner of the background square representing the door surface, an orange one anchored in the top left corner representing the surface of all other openings. As can be seen in the figure below cases when there are no openings at all, or only a door, strike out, as well as specific situations like clearances.

Fig 8 Bottom left, the visual formalism dedicated to highlighting the relative importance of openings in the overall surface of the façade. Two ”exceptions” (divergent behaviours inside the collection) are highlighted in this partial view, a clearance and a façade with no windows. Right, the making of the figure: the grey background square represents the overall surface of the façade, two squares of different colours are used to represent openings surfaces.

These three visual solutions are original designs, they do prove helpful although more user interactions should be added. At this stage, we use the classic “mouseover” event to trigger the opening of contextual information (names, positions, quantitative values *etc.*) and include some configuration buttons that switch on /off this or that graphic component such as coloured lines marking reference values (Fig 6) or dotted lines helping to compare the value of an element to this of others (Fig 7). A crucial interaction yet to implement is a user-monitored reordering of the columns.

Yet one thing is clear anyway: such solutions are not adequate if we wish to analyse the collection as such. They are of little help if the analyst needs to understand for instance if there is a global tendency going this or that way inside the data set. In short, they do not allow for the identification of patterns corresponding to the collection as a whole. As a consequence, we decided to also try out some collection reading visual formalism, and decided on reinterpreting two classic solutions: parallel coordinates and distribution plots.

In this implementation of the *parallel coordinates* formalism, each vertical bar (greyish vertical rectangles) represent the maximum and minimum values for one variable across the collection.

In our collection of edifices, values of the ratio *width of the bell tower vs. width of the façade* are between 14.4% and 51.6%: the first (leftmost) bar maps this information, the bottom of the bar corresponds to a quantity of 14.4, the top to a quantity of 51.6, and other values are distributed vertically accordingly.

The *parallel coordinates* formalism is used to try and spot clusters of values - edifices that share a feature, like for instance a common width/height ratio. It can also be of great used to analyse the distribution of values for a parameter (grouping of values in a small part of each vertical scale, like in this example in the next-to-last vertical scale, representing surfaces of windows *vs.* surface of façade.)

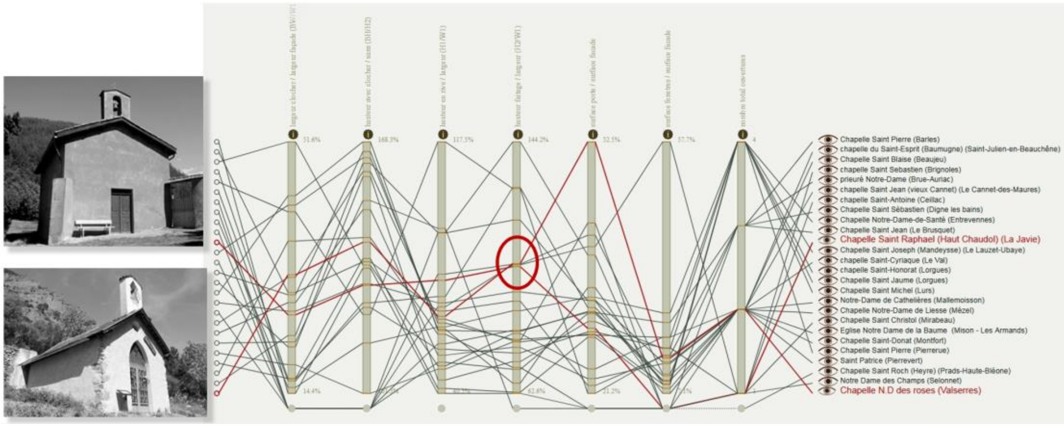

Fig 9 The *parallel coordinates* formalism reinterpreted to analyse clusters of values. The two edifices illustrated on the left images surprisingly belong to a common cluster, highlighted here by the red oval on the graphics: a same value for the H2/W1 proportion (height of the ridge of the roof / width of the façade).

Finally, we implemented another solution – a distribution plot - on bell tower proportions in comparison to façade proportions. The background square, divided in a grid of 10X10 equal parts, represents the width/height ratio of the facade (100%, 100%).

Each point corresponds to an edifice, its position on the x-axis conveys the information “width of the bell tower in comparison to this of the facade”, its position on the y-axis conveys the information “height of the bell tower in comparison to this of the facade" (Fig 10). Said more simply items left and above of the diagonal are bell towers thinner than the façade. Those positioned right and below of the diagonal, are flatter than the facade. On the diagonal are homothetic relations between the bell tower and the faced – only one as a matter of fact in our sample. In other words, homothetic relations are a most unusual situation, an observation that is in fact rather counter-intuitive.

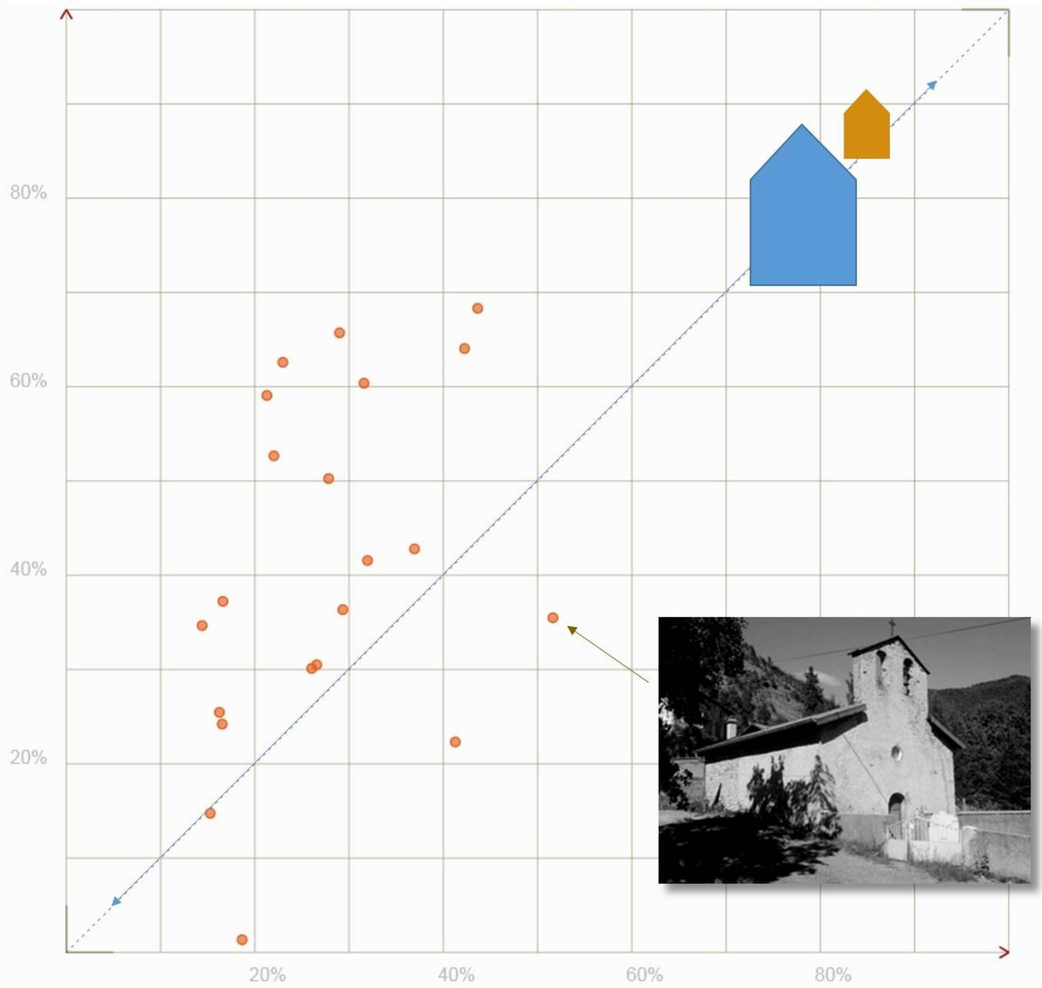

Fig 10 A *distribution plot* formalism reinterpreted in order to analyse differences in proportion between the bell tower and the façade across the whole collection. For only one edifice (point on the diagonal) there is a homothetic relation (see Fig 7). Points below the diagonal correspond to buildings with a bell tower "flatter" in proportion that the façade, illustrated here with the image on the right.

7. Potential benefits, limitations, future works.

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 » on the corpus we had selected - we do acknowledge that.

At this stage, some important limitations of the experiment need to be pointed out:

- the set of visualisations we have tested is far from being an ultimate choice (these visualisations are definitely perfectible),
- the amount, diversity, and even significance (for architects) of the ratios we have selected is questionable – the experiment is as said earlier a *proof of worthiness* experiment and nothing more,
- the data acquisition and processing pipeline is rather well adapted to the corpus selected (small-scale, rural chapels) but its applicability in the same context (non-experts called in to carry out the photographic survey) on larger edifices, or on more complex architectures, remains to be proven.

Still, 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 3D datasets seen as *hints about ways of building*. Of course, the whole approach does not require the computing of a 3D point cloud – we basically show that such a verbose output can be repurposed to back up and feed analyses.

We are now working on an extension of the initial research programme, an interdisciplinary research initiative entitled SESAMES, through which we develop a low-cost survey protocol designed for the extraction of significant architectural features from interior spaces (rather than from exterior facades). The photogrammetric protocol used bases on panoramic images, coupled with direct point to point measurements. The idea is, building on the same corpus of edifices, to investigate the potential added-value of the approach in terms of architectural analysis on a larger scale (more "proportions" observed, more data correlation scenarios).

Conclusion

We make no claim that the actual results presented in this paper do question in an unprecedented manner the global understanding we had of the corpus – although they do demonstrate a significant potential for supporting the data analyst's tasks.

The contribution is primarily intended at pushing to the fore the idea that, with more capacities to collect 3D data, and as a consequence with more data at hand, and in a sharable manner, analysts need to widen the of range of data interpretation modalities that can be called in at post-processing time. There naturally is a technological challenge here, since many 3D datasets cannot be post-processed easily due to the constraints of proprietary formats, for instance. But we believe there are here primarily methodological challenges, running all along the data acquisition process (ensuring the readability and exchangeability of 3D raw data) and the interpretation process (developing means to cross-examine data sets across case studies).

Our goal was to weigh the potential added-value of a somehow "low-tech" acquisition and processing chain – a chain that we consider best suited to the economy behind small-scale, vernacular heritage.

Hence the result we present should be understood as a contribution to a strengthening of the methodological bases on which the chain of operations that lead from a given survey campaign to what is sometimes called *sensemaking* may be grounded.

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