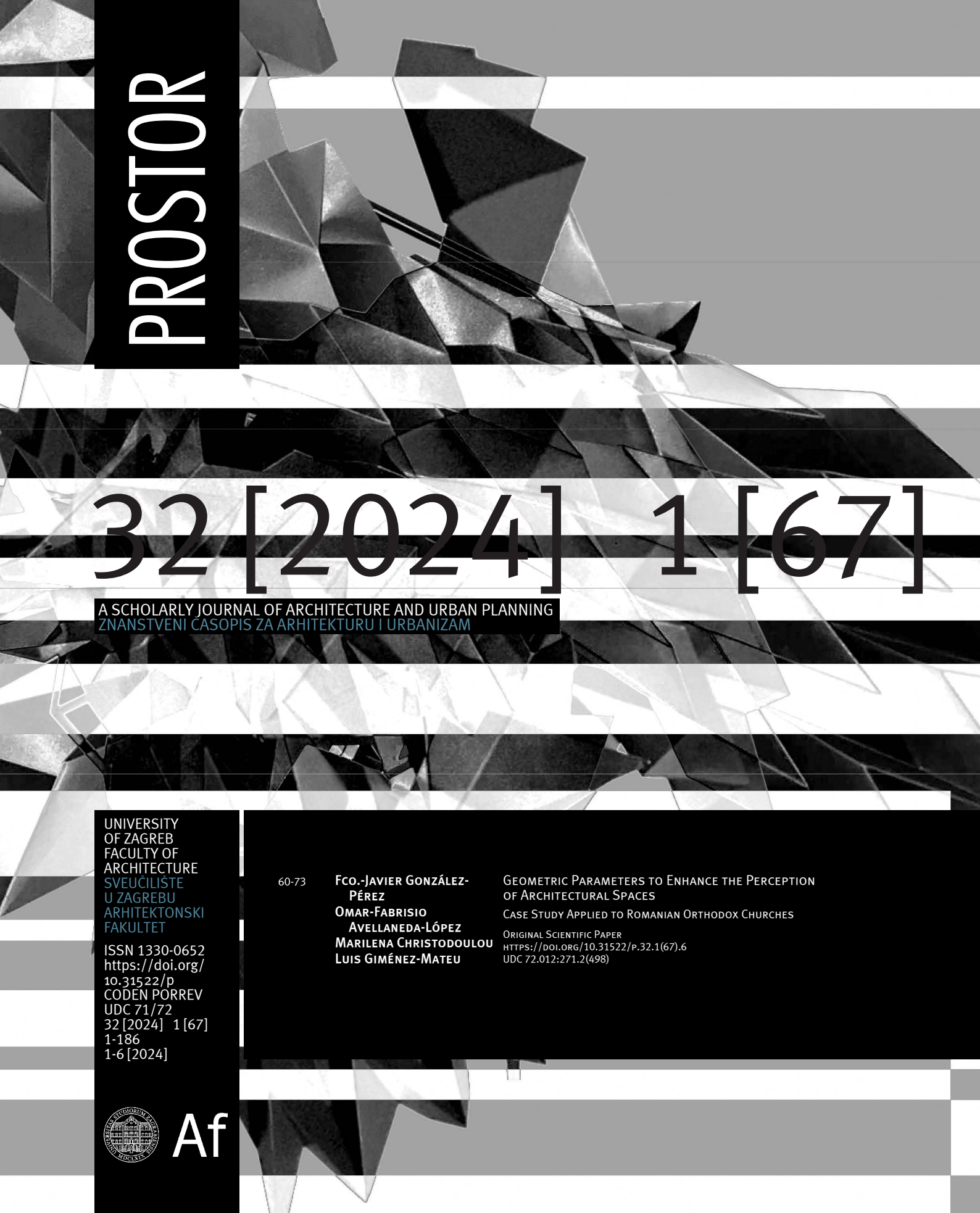

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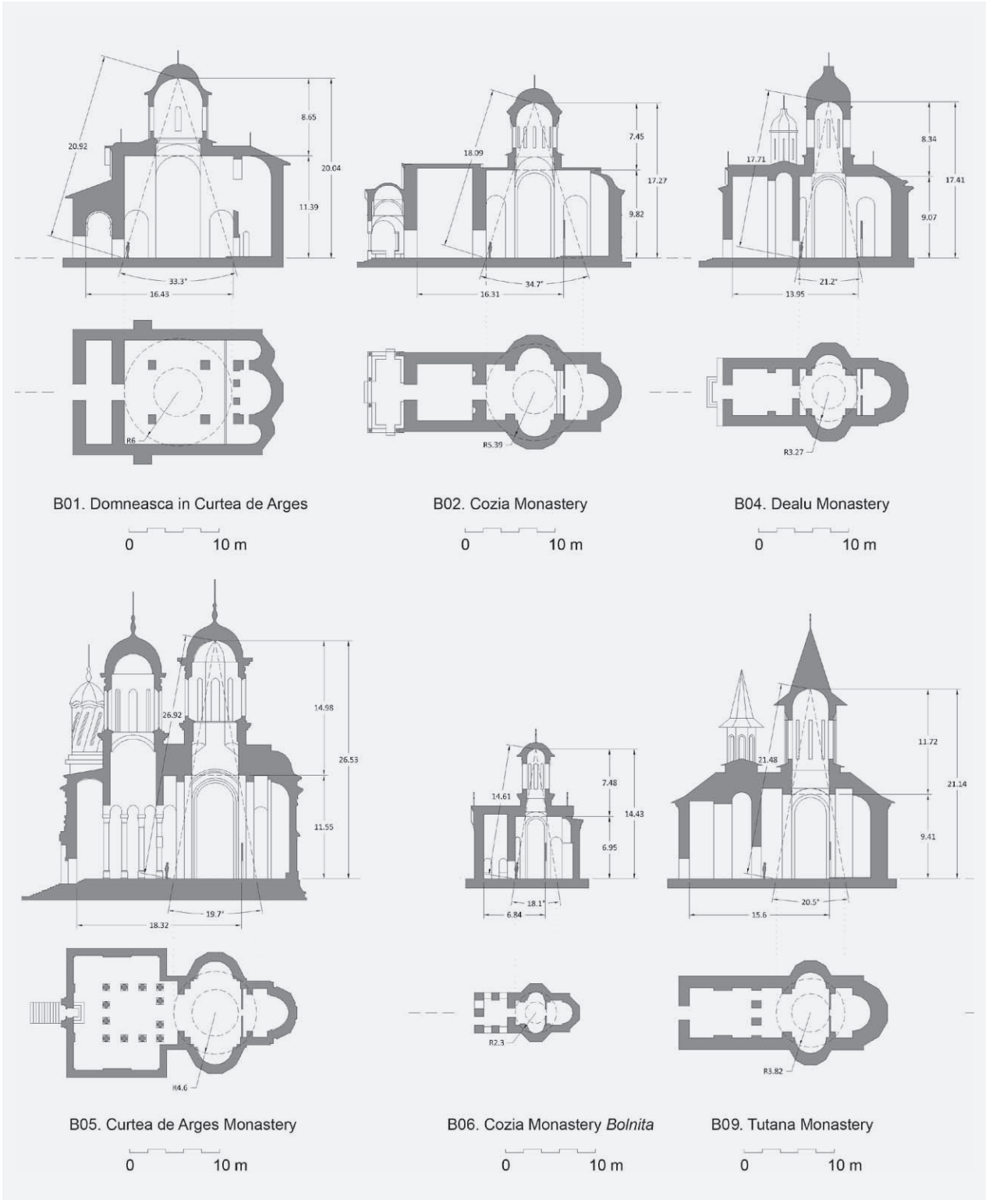

Fig. 1 Section comparison between relevant churches at the same scale

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Geometric Parameters to Enhance the Perception of Architectural Spaces

Case Study Applied to Romanian Orthodox Churches

architectural visualization
buildings classification
Orthodox churches
space emotions
spatial proportions

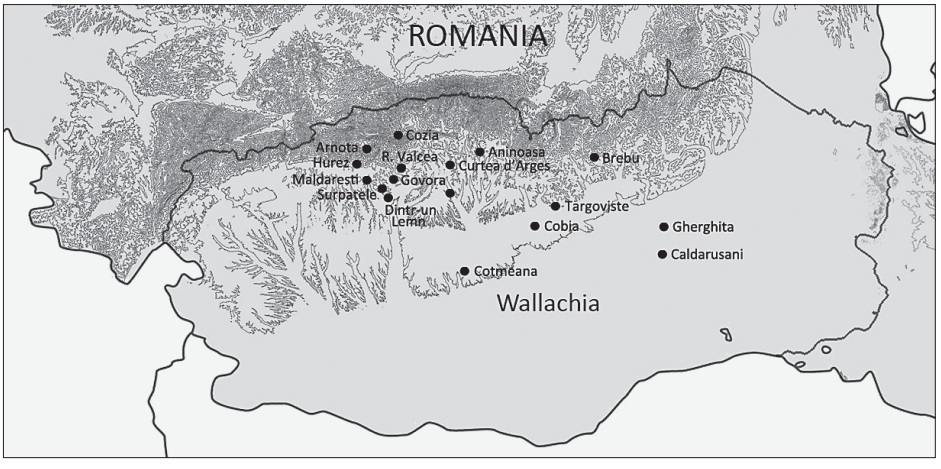
The challenge in obtaining objective parameters for evaluating the aesthetic appeal of buildings is what we try to explain through a case study, presenting a pioneering methodology that can be applied and adapted to different architectural styles. Our focus is on a substantial investigation of Romanian Orthodox churches in the Wallachia region, which exhibit striking similarities from their early stylistic developments in the 16th century to contemporary examples. By examining the geometric relationships within their interior spaces, we aim to derive objective insights that enable an alternative classification. This classification, in turn, helps us measure the emotional impact these spaces have on users or visitors, influencing emotions based on spatial proportions. Through these relationships, we can evaluate the importance of different buildings of the same category, classify them and, objectively explain their differences. Applying the findings of this study, along with specific variables, to other architectural contexts allows us to address user preferences more effectively to enhance architectural designs by improving comfort and the quality of life.

Introduction

The present architecture of Romanian Orthodox churches is a testament to a rich tradition that traces its roots back to ancient Byzantine models, remarkably preserved to this day. Every architectural facet responds to worship needs and the technical conditions of constructing a new church. These considerations have given rise to a distinctive style, preserved for centuries, with recent churches in Romania and beyond, continuing in the same tradition.

The research conducted in the 1930s by the Commission of Historical Monuments in Romania, led by architect Nicolae Ghika-Budesti, marked the first serious attempt to register and classify Romanian Orthodox churches in the historical Wallachia region, now Muntenia and Oltenia in southern Romania (Fig. 2). Ghika-Budești and team extensively surveyed churches and monasteries, meticulously documenting them to create the first comprehensive register of Wallachia's Orthodox heritage. They classified monuments by style and era, elevating to the category of historical monuments those that best identified the styles of each era, from the beginning of the s. XIV until the end of its golden period, in the s. XIX, focusing on their stylistic aspects, analysing external features, construction techniques and various formal aspects observed during execution (Ghika-Budesti, 1927, 1930, 1933, 1936).

Fig. 2 Romania map within the Wallachia region and the churches under study



Wallachian churches have a distinct and expressive interior characterized by the configuration of spaces, proportions, connections and the play of light or colours on the walls that define the character of each church. A distinctive feature is the slender space, which could be likened to a tower, beneath the church dome.

While the dome base is the external form that most clearly identifies these buildings as churches, it is not merely a formal tool; its function is integral to worship and can only be understood within the church. The base of the dome serves as a support and division for the dome itself, which contains the image of Christ Pantocrator. This portrayal symbolizes Jesus and the heavens in a contemplative manner, as he gazes down upon the congregation. This visual relationship influences the squared anatomy of the nave and establishes proportions that condition different metric parameters defining the geometry of the lantern tower and the nave. Aspects, as we will see below, studied by Nikos K. Moutsopoulos (Moutsopoulos, 1962) and Cecil L. Striker (Striker, 1995). Moutsopoulos examined a variety of Greek cross-square churches, and Striker applied the same analysis to the churches of Constantinople, with similar results. According to research, the layout of the plan and the elevation determination may have been two distinct activities, and the relationships inside the building may be better described as architectural than as geometric.

From the perspective of the believer seeking a meaningful spiritual experience, perceptual parameters, often intangible, differentiate one church from another. These parameters depend on metric or visual relations and spatial proportions, making functions measurable and tangible concepts. This text aims to analyse rational parameters among specific measurements of various Romanian Orthodox churches, enabling a comparative assessment from the believer's standpoint.

Comparing Churches

When viewed collectively, it's evident that Orthodox churches in Wallachia exhibit a remarkable similarity to one another, both in their internal arrangements and external appearances. This often leads the region's residents, perhaps exaggerating a bit, to perceive all these churches as identical. Admittedly, such a perception is not entirely accurate in the strict sense, but it's not entirely unjustified. Primarily designed to serve their respective communities, these buildings were replicated throughout the territory, with varying degrees of fidelity to the original pattern but without a deliberate effort to make each structure unique.

In a way, this viewpoint contrasts with the study mentioned earlier by Ghika-Budesti and the Commission of Historical Monuments of Romania, published in 1936. Despite the catalogue format, Budesti's essay includes a table proposing a specific classification of the documented churches (Fig. 3).

The table serves more as a graphic synthesis, as the study was not intended for typological analysis. Instead, it aims to respond to criteria that might be considered anecdotal or less relevant from an architectural standpoint.

While these criteria are relatively common in Byzantine architectural studies, they remain open to questioning, as highlighted by Professor Cyril Mango when referring to these types of studies: "*... Buildings are labeled and pigeon-holed like biological specimens according to formal criteria: where a resemblance is found a connection is assumed even across a wide gulf in time and space. A simplistic system of classification may thus set up artificial categories and can easily misdirect scholarly inquiry.*" (Mango, 1991: 41)

Certainly, attempting to link two churches by, for example, the number of columns in the porch or archivolts on the lantern tower's windows could lead to artificial conclusions. However, this doesn't necessarily mean that comparative analysis should be discarded. Despite the architectural uniformity of Wallachian churches, the perceptual experience suggests they are not identical. The sensations and emotions experienced by visitors and believers also vary, and although outside the scope of this study, they may be a possible line of research as indicated in the conclusions.

These differences don't rely on the parameters typically considered in art history studies but are perceptible to visitors, presenting nuances that may be observed through certain dimensions.

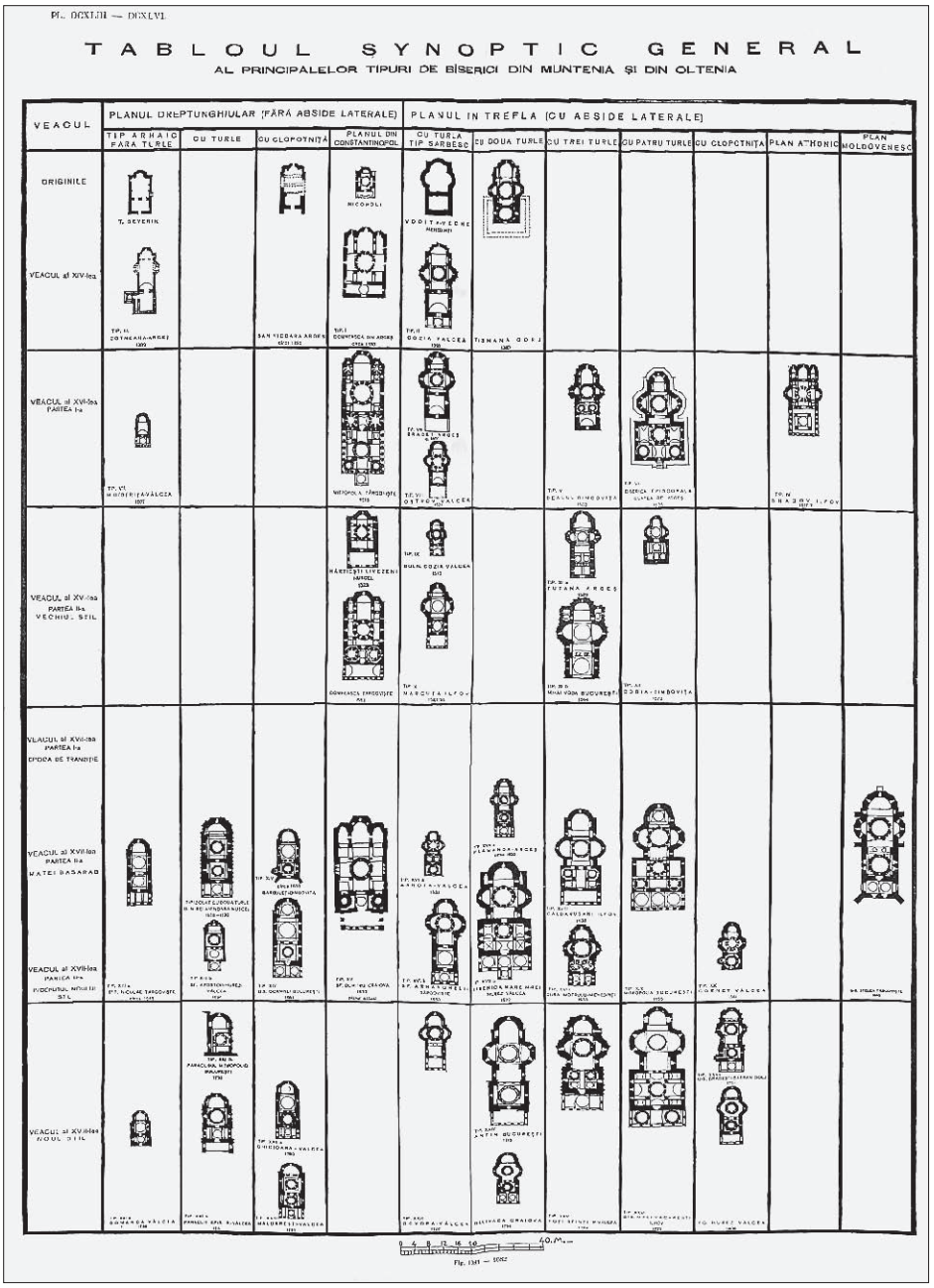


Fig. 3 Final classification table of churches from the 14th to the 18th century carried out by the Commission of Historical Monuments in Romania

The Scale

Referring to Byzantine constructions, architectural historian Robert Ousterhout highlights the significance of scale as the most crucial aspect. He laments that discussions about function and typology often overlook this factor, stating: "*... scale is the hardest aspect of architecture to convey without an actual site visit, but it was probably the critical factor in the selection of a plan or a building type. From a purely practical point of view, buildings of different sizes demanded differ-*

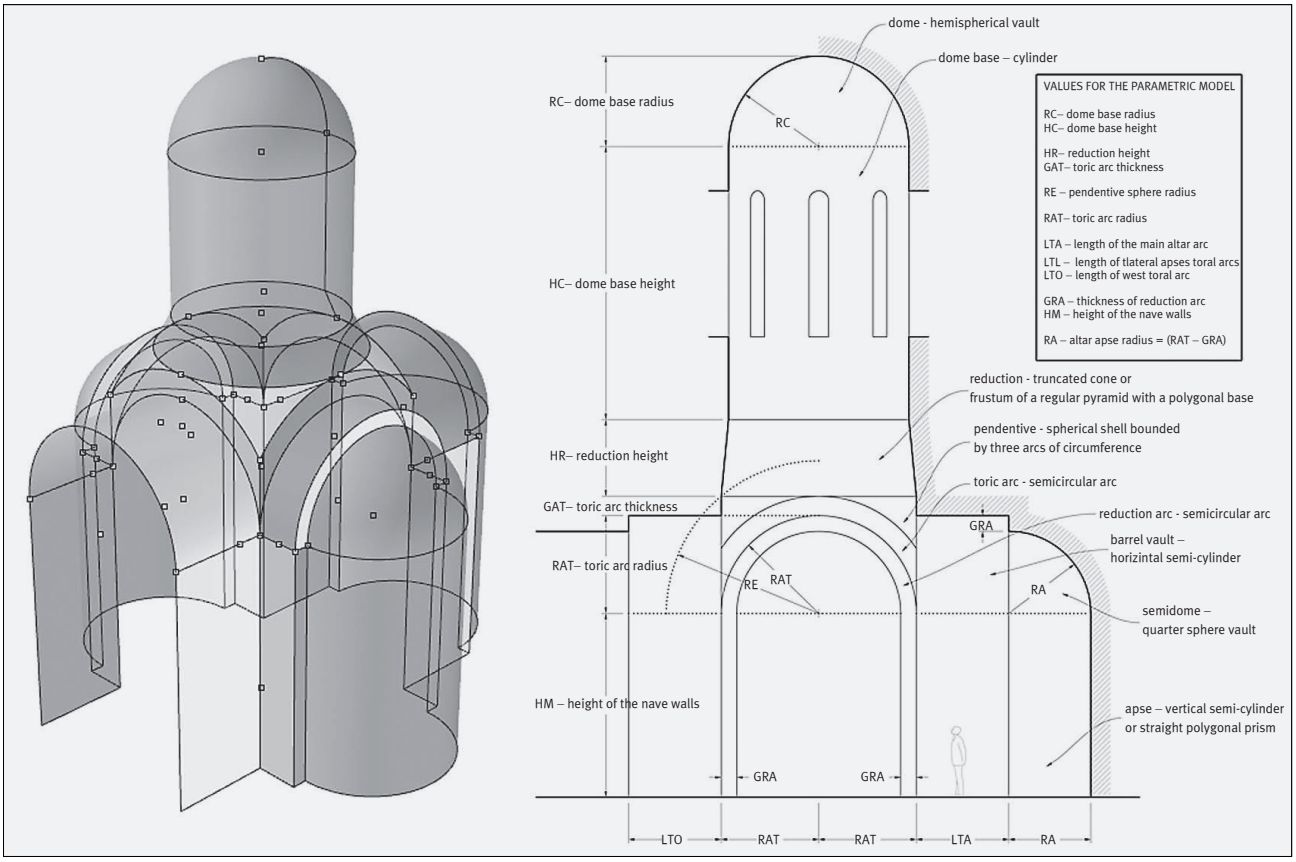


Fig. 4 Parametric model of the inner shell of a church, valid for all those in the study

ent structural systems, and thus the development of various church "types" may have come from a consideration of scale." (Ousterhout, 1999: 30)

Indeed, all construction systems have their limitations in terms of dimensions. In this paper it's deduced that it's impossible to scale the same typology infinitely. The increase of charges and efforts requires changes in construction techniques, altering the geometry. Even if we stick to the same typology, it becomes apparent that scale plays a significant role in differentiating churches (Fig. 1). Even with maintained geometric structures and proportions, the scale notably influences the relationship between individuals and architectural space. Consequently, the perception differs in a small church compared to a more expansive one.

Scale, by definition, is a relative value rooted in comparison. So, when we talk about a church having a larger or smaller scale, it's always in comparison to another. Undoubtedly, the most accurate way to assess the scale of one church relative to another is by comparing their respective graphic representations at the same scale. This fundamental principle is unfortunately often overlooked in publications, with some positive examples as in Curcic's book on architecture in the Balkans (Curcic, 2010).

The Parametric Model

In all the various trefoil and single nave plans (the rectangular ones without side apses), the same geometric setup is repeated within the nave: the square floor plan is created by connecting four piers with four toric arches at the top. The gaps between piers match the arches' diameter, and the sections of the piers are the same size as the arches.

Right on top of the keystone of those four arches, there's a ring or horizontal hoop, forming the base of the lantern tower. So, unless someone decides to make things smaller, the lantern tower's diameter is the same as the arches, which, of course, is also the gap between the piers in the nave. The part between the arches and the lantern tower is built with shells that support the weight of the dome on the arches, as in "Aproximación de superficies para la ejecución de bóvedas tabicadas" (Giménez-Mateu, Navarro and Cabrera, 2016).

The lantern tower culminates with a dome of the same diameter or, in the absence of plans

Table I Table of main interior dimensions gathered in the study

	dome base radius	dome base height	reduction height (if any)	toric arcs thickness	toric arc radius	length of the main altar arc	length of lateral apses toral arcs	length of west toral arc	thickness of reduction arc (if any)	height of the nave walls	altar apse radius = (RAT - GRA)
Church selection from 26 examples	**RC**	**HC**	**HR**	**GAT**	**RAT**	**LTA**	**LTL**	**LTO**	**GRA**	**HM**	**RA**
01. Domneasca of Curtea de Arges	273	398	65	129	251	366		350		888	251
02. Cozia Monastery	205	396		144	219	405	70	320	34	763	185
04. Dealu Monastery	160	630	20	24	163	327	73	141		744	163
05. Curtea de Arges Monastery	242	1189		37	260	325	92	83		924	260
06. Cozia Monastery Bolnita	100	450	148	50	119	173	18	111	19	576	100
09. Tutana Monastery	200	704	202	67	212	527	62	333	36	729	176
11. Domneasca of Targoviste	253	596		47	253	607		284		911	253
13. Arnota Monastery	127	402	98	53	137	227	35	122	22	454	115
15. Dintr'un lemn Monastery	154	775		40	154	218	34	86	20	487	134
16. Brebu Monastery	240	634	231	104	296	307	39	327	38	638	258
17. Caldarusani Monastery	250	545	500	30	235	676	31	359		545	235
19. Stelea of Targoviste Monastery	212	715	275	35	306	231		343	45	540	261
21. Govora Monastery	205	648		30	205	232	30	144	30	589	175
22. Aninoasa Monastery	223	423	87	47	270	267	28	125		518	270
23. Hurez Monastery	230	736	75	45	267	420	80	308	48	753	219
24. Maldaresti church	125	436	53	42	190	158	64	63		409	190
25. All Saints of Ramnicu Valcea	225	933	125	54	245	142	54	88		743	245
26. Surpatele Monastery	180	532	105	47	194	229	32	135	28	550	166
Average among the 18 churches (cm units)	**200,22**	**619,00**	**152,62**	**56,94**	**220,89**	**324,28**	**49,47**	**206,78**	**32,00**	**653,39**	**203,11**

to expand the nave, a diameter that corresponds to the toric arches. As mentioned, this diameter aligns with the separation between the piers of the nave. Similarly, without reductions, this pier separation determines the width of the apse and, consequently, the diameter of the quarter-sphere vault over the altar. Meanwhile, the square shape of the nave's floor plan ensures that the lateral apses have dimensions identical to those of the altar's apse.

In summary, in a church without geometric reduction (which is the majority), the separation between nave piers determines the diameters of the dome, lantern tower, apse, and corresponding spherical vaults. Essentially, nearly all dimensions of the church hinge on this single parameter. The model's geometry is precisely defined by the separation between piers, determining whether it expands or contracts. This singular variation in scale supports the argument that those who claim all churches are the same may be right. These geometric conditions establish direct links between the dimensions of various elements and those of churches parameterized through the 3D parametric model (Fig. 4). The model showcases real-time geometric connections, demonstrating the impact of modifications in any of these dimensions on the entire structure.

The Metric of the Churches

The examination of historical models by Ghika-Budesti reveals that the historical expansion of Orthodox churches across Wallachia's territory was rooted in the repetition of a standardized model with a few variations. This repetition often involves a direct reproduction of an existing church taken as a template. However, it's not uncommon to observe variations in dimensions while maintaining the same typology. In this section, our goal is to assess the extent of these variations in each case, considering their extreme values as well as their average.

By selecting the most significant models identified in the Commission of Historical Monuments study, a statistical projection has been undertaken based on a sample of 18 significant churches (Table I). While the sample size is relatively small and non-randomly chosen, the model status of these selected churches deems them adequately representative within the total set of Wallachian churches. With this consideration in mind and leveraging a parametric model, we have

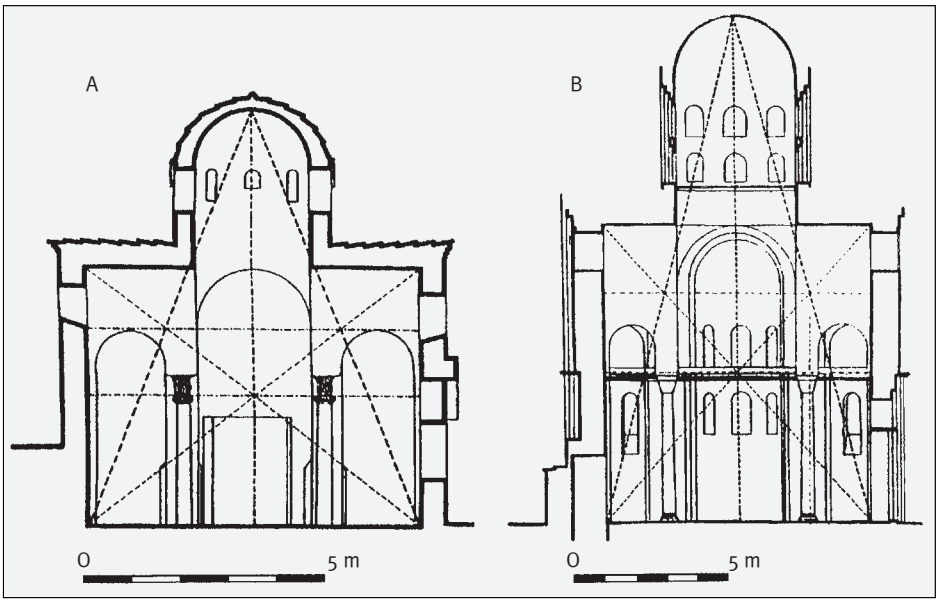


Fig. 5 Diagrams with the "harmonic sections" in Byzantine churches: A – Church of Saint John the Theologian, Athens; B – Church of Panagia Chalkeon, Thessaloniki

generated tables that, in turn, facilitate further analysis and reflections, leading to several interesting conclusions.

The comparative table presented (Table I) indicates that the distance between piers (RAT×2) has an average value of 4.40 m, resulting in an average surface area of the square nave at 19.36 m² (4.40²). If we associate this value with the current density standards for places of worship (0.25 m²/person), the capacity is estimated at 77 people (this number should be reduced if the area adjacent to the presbytery is unsuitable, for the purposes of affordability, but here it is considered compensated with the additional surface of the lateral apses). The table also reveals that B02-Monastery of Cozia is the church closest to the average value (4.38 m), followed by B09-Monastery of Tutana (4.24 m) and B21-Govora (4.10 m). These can be considered references for medium-sized churches in Wallachia. Furthermore, the maximum nave area is observed in B19-Stelea of Targoviste with 37.45 m² (6.12²), with a capacity of more or less 150 people. This aligns with expectations, considering it's an example of a church with a Moldavian vault[1] type, allowing for a broader nave. Conversely, the smallest value is found in B06-Bolnita of Cozia, with 5.66 m² (2.38²), suitable for only 23 well-distributed people.

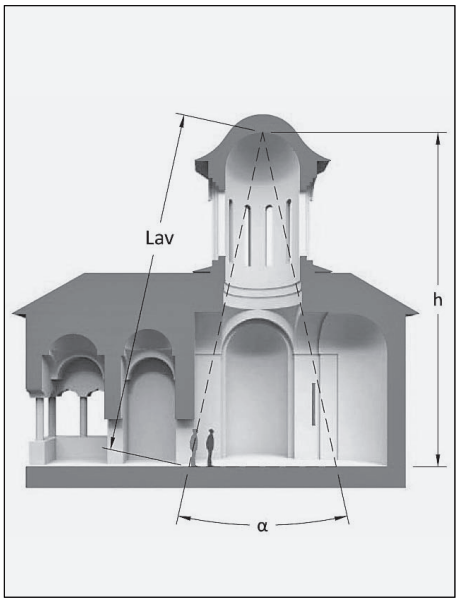
It's noteworthy that while the majority of the plan's measurements are tied to the separation between piers, the height of the nave and the lantern tower are independent of the plan's dimensions. There is no doubt, however, that these are two transcendent measures in the architectural definition of these spaces. It makes sense, therefore, to make comparisons within the framework and draw some conclusions from them.

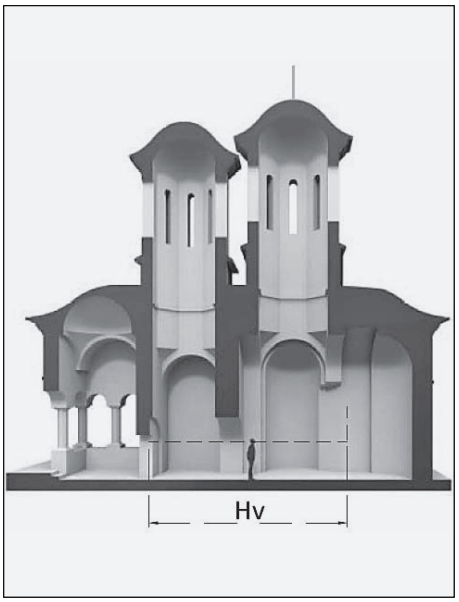
The Applied Geometry

The builders of Wallachian churches remain anonymous figures without written evidence about their patterns and technical references for projecting and constructing these buildings. Due to their typological simplicity and the consistent repetition of the same scheme, they likely had a strong command of the geometric relationships between arcs and domes. Unfortunately, we lack precise information about their technical knowledge or construction strategies, even though advanced studies have been conducted on historical examples of Byzantine constructions in Constantinople. These studies commonly refer to empirical geometric layouts as regulators of the patterns used. A contribution that must be cited, prior to that of Moutsopoulos, is that of "He Aisthetike tou Chorou tes Hellenikes Ekklesias sto Mesaiona" (Kalligas, 1946). However, it was the historian Moutsopoulos, who examined Greek churches with a Greek cross inscribed plan. Analyzing geometric relationships in the cross-section of the naves, he identified an isosceles triangle with its base representing the dimension of the nave's floor and its top vertex at the zenith of the dome's lantern tower (Fig. 5). Repeating this process for various churches with different proportions, he observed that the two symmetrical sides of the triangle consistently passed through the keystone of the corresponding toric arch. This geometric scheme established a relationship between the transversal sections' maximum length and the height of the nave, as well as the diameter and height of the lantern tower (Moutsopoulos, 1962). Archaeologist and architectural historian Striker conducted a similar study on the churches of Constantinople, obtaining comparable results in the text "Applied Proportions in Later Byzantine Architecture" (Striker, 1995). Even when comparing two churches with the same nave width, the height and diameter of the lantern tower were determined by the aforementioned isosceles triangle.

Both studies focus on the interior of the churches, disregarding their exterior forms.

1 This is a support system structured in two levels to reduce the diameter of the dome: the lower level consists of the usual four half-point arches, with four pendentives at the corners to form the circle; then, at a second level, four new diagonal half-point arches are arranged, starting from the respective keystones of the arches at the first level; finally, four new pendentives at the angles of these new arches define a new circle, with a considerably smaller diameter than the first one, from which the dome rises.





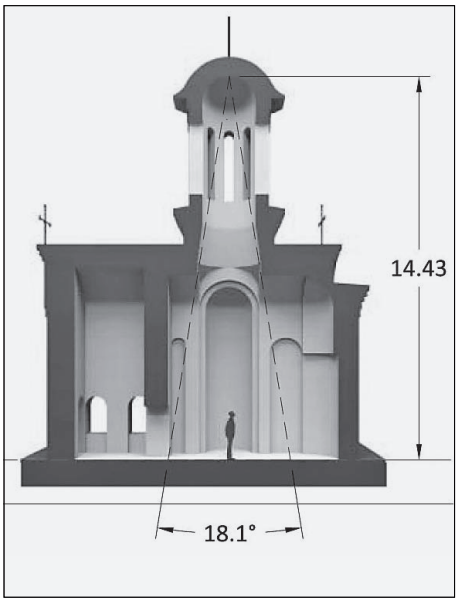


Fig. 6 Graphical definition of *Lav* (low angle view) parameter

Fig. 7 Graphical definition of *Hv* (horizontal view) parameter

Fig. 8 Graphical definition of *SD* (slenderness) parameter. α represents the angular aperture of the inscribed cone.

This approach aligns with the logic of Orthodox Christianity, where the church's interior holds the utmost symbolic and essential significance. Considering that defining the soffit is a crucial step in church construction, emphasizing the interior geometry also makes sense from a constructive standpoint. Therefore, the geometry of the interior significantly influences the shaping of the exterior through the formwork.

The Perception Coefficient

Using the 3D model, we applied the layouts proposed by Moutsopoulos and Striker – already cited – to both transversal and longitudinal sections of the previously analysed Wallachian churches. The outcome reveals nearly identical sections in both directions, a logical result given the consideration of square plans with double symmetry. However, the visual relationship between believers and the Pantocrator figure (dome) holds paramount importance in the symbolic realm of Orthodox rituals. Consequently, the naves of the churches are proportionally scaled to ensure a clear view of the Pantocrator from any point on its floor.

• **The Low angle view** *(Lav)* – Upon entering the nave from the narthex, the believer's gaze spans a visual journey from the iconostasis (horizontal view at eye level) to the Pantocrator (low angle view), covering a vertical angle of approximately 80°. Given the proportions of these churches, the low angle view of the Pantocrator represents the lengthiest visual experience within the building, marking a mystical zenith for the believer entering the nave. Positioned within the section, the low angle view aligns with an inclined line originating from the zenith of the dome's lantern tower, passing through the keystone of the toric arch, and reaching the ground at the nave's floor limit. As the nave is bi-symmetrical, this low angle view replicates identically in the side apses and the presbytery. Therefore, it is logical to conceptualize the cone generated by rotating this visual line around a vertical axis passing through the dome's zenith, appropriately labelled as "the nave's cone."

The length of the low angle view *(Lav)* quantifies this essential aspect of the believer's visual experience in the nave. Expressed as $Lav = h / \cos(\alpha/2)$, where h denotes the height of the cone's vertex, and α represents the aperture angle (Fig. 6).

The base of the dome's cone defines the area from which the toric arches do not obstruct the view of the Pantocrator. In the majority of the cases under study, the floor plan of the nave is dimensioned using the circumference of the cone's base as a template. This approach ensures that the distance between the center of the nave and the walls, whether from the narthex, the lateral apses, or the iconostasis, approximates the radius of the said circumference.

• **The horizontal view** *(Hv)* – If, before entering the nave, the visitor's sight is shorter than the low angle view of the Pantocrator, it creates a significant contrast in their perception. This effect, ranging from surprise to admiration, becomes more pronounced if the narthex is shorter or if the wall separating it from the nave has a particularly small opening.

Table II Table with the alternative classification by Perception Coefficient value

	vertical lenght from pavement to pantocrator	distance from entry to iconostasis	distance from nave entry to pantocrator	Low Angle View / Horizontal View	opening angle in degrees	ratio between cone base and interior height	**Contrast + Slenderness**
Church selection from 26 examples	**Interior height**	**Horizontal View**	**Low Angle View**	**Contrast**	**Cone opening angle**	**Slenderness**	**PERCEPTION COEFFICIENT**
01. Domneasca of Curtea de Arges	2004	1643	2092	1,27	33,3	1,67	2,94
02. Cozia Monastery	1727	1631	1809	1,11	34,7	1,60	2,71
04. Dealu Monastery	1741	1395	1771	1,27	21,2	2,67	3,94
05. Curtea de Arges Monastery	2652	1832	2692	1,47	19,7	2,88	4,35
06. Cozia Monastery Bolnita	1443	684	1461	2,14	18,1	3,14	5,28
09. Tutana Monastery	2114	1560	2148	1,38	20,5	2,77	4,14
11. Domneasca of Targoviste	2060	1623	2129	1,31	29,2	1,92	3,23
13. Arnota Monastery	1271	705	1293	1,83	21,0	2,70	4,53
15. Dintr'un lemn Monastery	1610	852	1628	1,91	17,0	3,35	5,26
16. Brebu Monastery	2143	2214	2206	1,00	27,5	2,04	3,04
17. Caldarusani Monastery	2105	2036	2149	1,06	23,1	2,45	3,50
19. Stelea of Targoviste Monastery	2083	1714	2137	1,25	25,8	2,18	3,43
21. Govora Monastery	1677	1086	1713	1,58	23,5	2,40	3,98
22. Aninoasa Monastery	1568	1427	1647	1,15	35,7	1,55	2,71
23. Hurez Monastery	2106	1739	2158	1,24	25,3	2,23	3,47
24. Maldaresti church	1255	921	1280	1,39	22,8	2,48	3,87
25. All Saints of Ramnicu Valcea	2325	1578	2364	1,50	20,8	2,72	4,22
26. Surpatele Monastery	1608	918	1646	1,79	24,8	2,27	4,07
Average among the 18 churches (cm units)	**1.860,67**	**1.419,89**	**1.906,86**	**1,42**	**24,67**	**2,39**	**3,81**
	cm	cm	cm		degrees		

Another noteworthy perspective is the horizontal view when the visitor enters the church and faces the altar. Through the openings in the narthex, the framed view extends from the door to the iconostasis. It serves as the first visually striking image upon entering the church, providing the initial perception of its interior dimensions, which are challenging to gauge from the outside (Fig. 7).

• **The contrast** *(Ct)* – To enhance the comparison of different churches, we introduce a new parameter called contrast *(Ct)*, defined as the proportional relationship between the lengths of the low angle view *(Lav)* and the horizontal view *(Hv)*.

$$Ct = Lav/Hv$$

A contrast value of 1 would suggest that the two views are of equal length, while values greater than 1 indicate a greater vertical depth of field than horizontal. The perceptual experience suggests that higher contrast leads to a more significant impression on the visitor.

This parameter can be calculated for all churches with a lantern tower, allowing for comparisons regardless of their size, geometry, or the nave's position. It is also applicable to churches with an inscribed Greek cross plan, although, in this case, the nave may have shaded areas outside the nave's cone, where a direct view of the Pantocrator is not available.

In the majority of the studied examples, the low angle view is longer than the horizontal, resulting in a contrast larger than 1. There are only two cases where the value decreases almost to 1, namely B16-Brebu and B17-Caldarusani. It doesn't appear coincidental that these churches also deviate from the rule of the nave's cone. In these two large churches, it is possible that their reconstruction or adaptation was not considered, possibly due to ignorance, of the empirical rules that the ancient builders seemed to have had quite clear.

• **The slenderness** *(Sd)* – Slenderness is introduced as a new parameter directly linked to the angular aperture of the cone (Fig. 8). Regardless of the church's scale and size, a smaller angle results in a slimmer nave. Therefore, the slenderness *(Sd)* value can be calculated as the ratio between the base of the cone and its height:

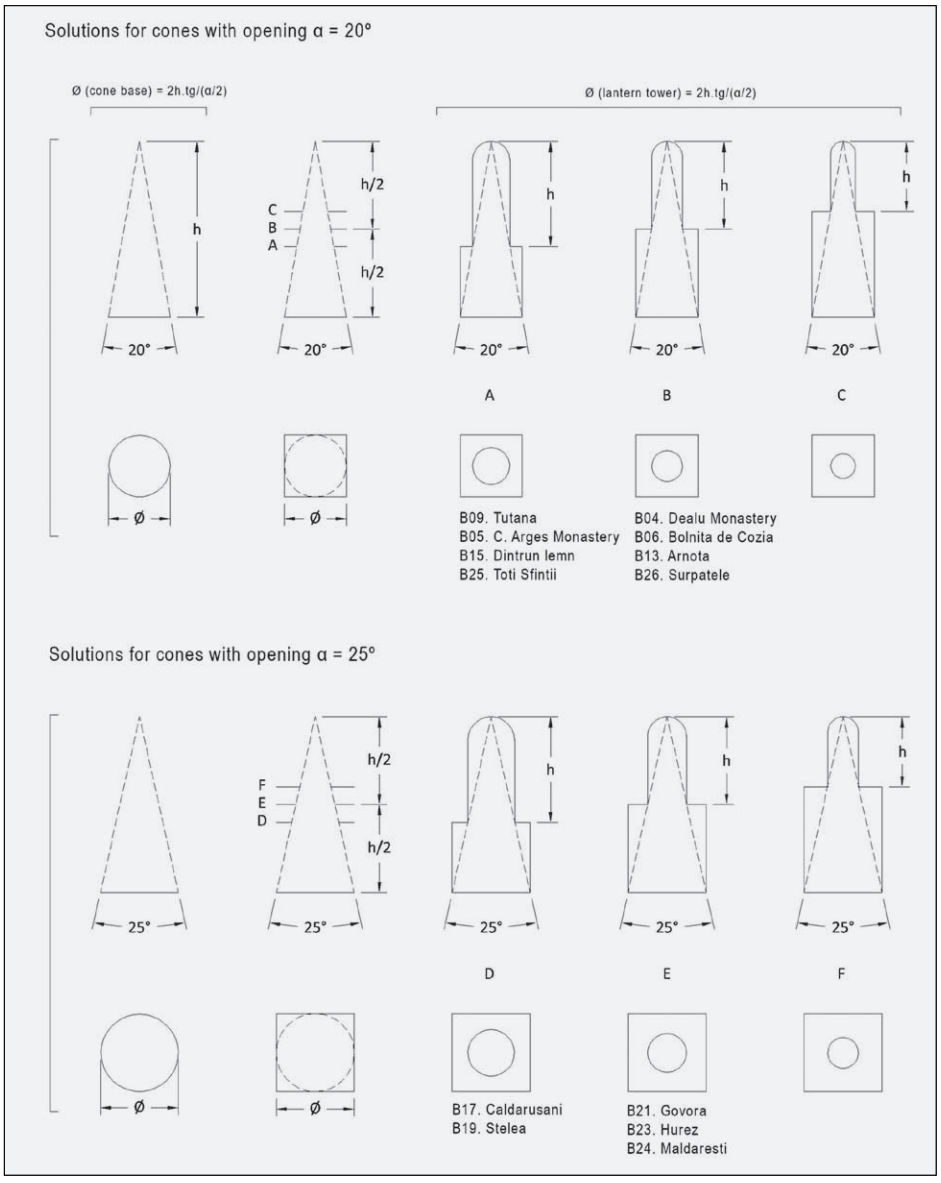


Fig. 9 Some examples are shown for different openings at 20° and 25°, combined with different variants of dome height

$$Sd = 0{,}5 / tg(a/2)$$

It is found that the small churches, such as Bo6-Bolnita of Cozia or B15-Dintrunlemn, they are slenderer, with cone opening angles of 18.1° and 17°, respectively. On the other hand, cases like B22-Aninoasa or Bo2-Monestir of Cozia, they turn out to be less slender, considering their large dimensions, with angle values of 35.7° and 34.7°, respectively.

Slenderness is quickly noticeable in the section due to the lantern tower's cylinder proportion. Visitors often appreciate more slender and stylized churches. In addition to contrast, slenderness is a parameter universally applicable to the interior spaces of churches.

• **Perception Coefficient** *(PC)* – Both contrast and slenderness are quantifiable numeric values applicable to the models under study. As products of the relationship between two measurements, they are objective and measurable. By combining these two values, a third value is obtained, referred to as the "Perception Coefficient" *(PC)*. This coefficient allows for the classification of churches based on symbolic proportions intrinsic to Orthodox churches. In this study, the PC is a size-independent value focusing on the essence of the inner sacred space. A classification based on the PC enables arranging churches by objective parameters that reflect their symbolic significance and the impressions they convey to visitors.

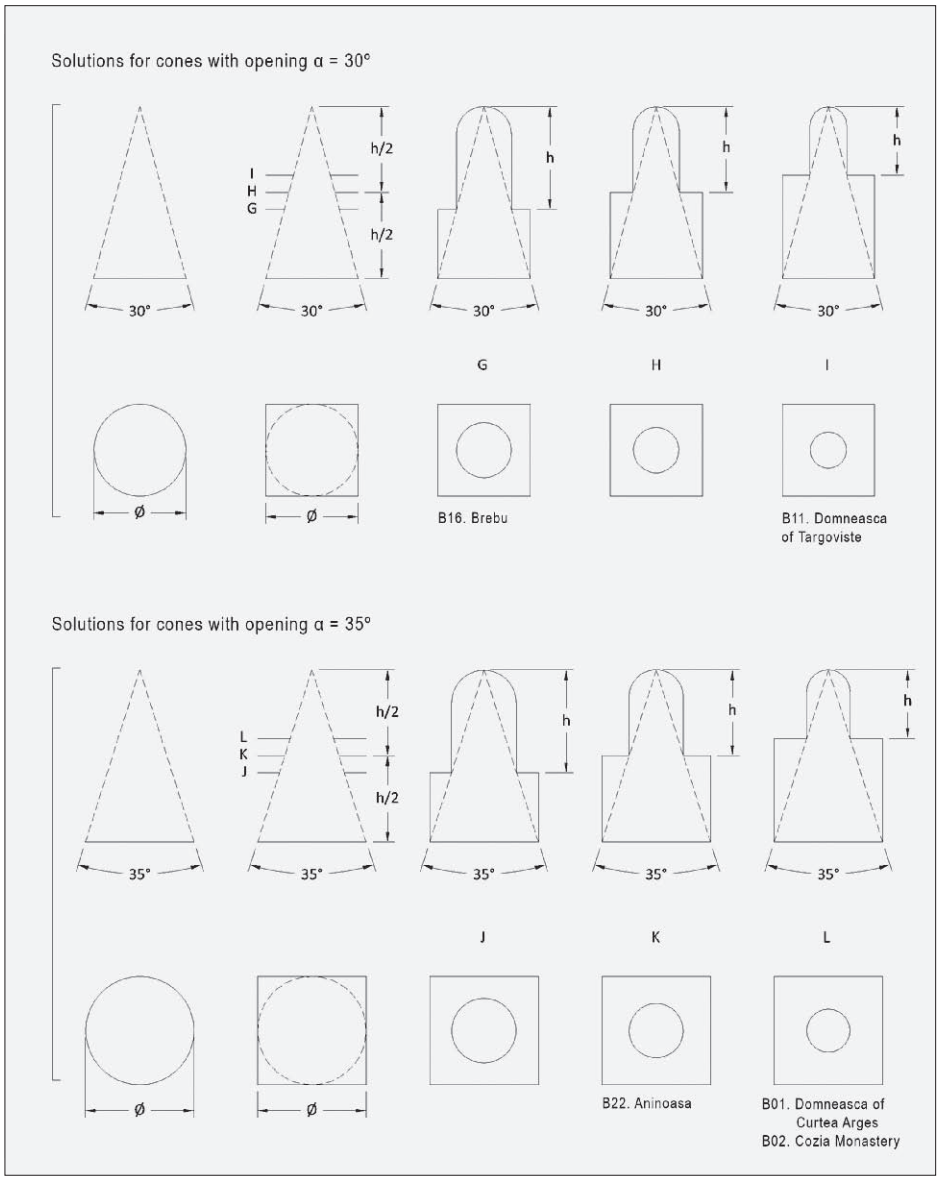


Fig. 10 Some examples are shown for different openings at 30° and 35°, combined with different variants of dome height

The Alternative Classification

Thus, the Perception Coefficient *(PC)* is the addition of contrast *(Ct)* and slenderness *(Sd)*. The churches that perform best in the application of the Perception Coefficient *(PC)* and have smaller dimensions are B06-Bolnita of Cozia with 5.28, B15-Dintrunlemn with 5.26, and B13-Arnota with 4.53 (Table II). From these results, it is reasonable to infer that smaller churches tend to exhibit better proportions.

However, the classification presents two large churches, B05-Monastery of Curtea de Arges and B25-All Saints of Ramnicu Valcea, in the fourth and fifth places, respectively. These two churches have a small narthex and a slender lantern tower. Yet, they should have been excluded from the list since they did not fulfil the first condition: that the nave's cone is equivalent to the plan's dimensions.

Conversely, the least well-performing churches are those with a large narthex and a relatively low and wide lantern tower. This includes the cases with an inscribed Greek cross plan: B01-Domneasca of Curtea de Arges, B11-Domneasca of Targoviste, B15-Brebu, and B22-Aninoasa.

In numerical classifications, extreme values are often not the most representative due to polarization. Excluding these values, more

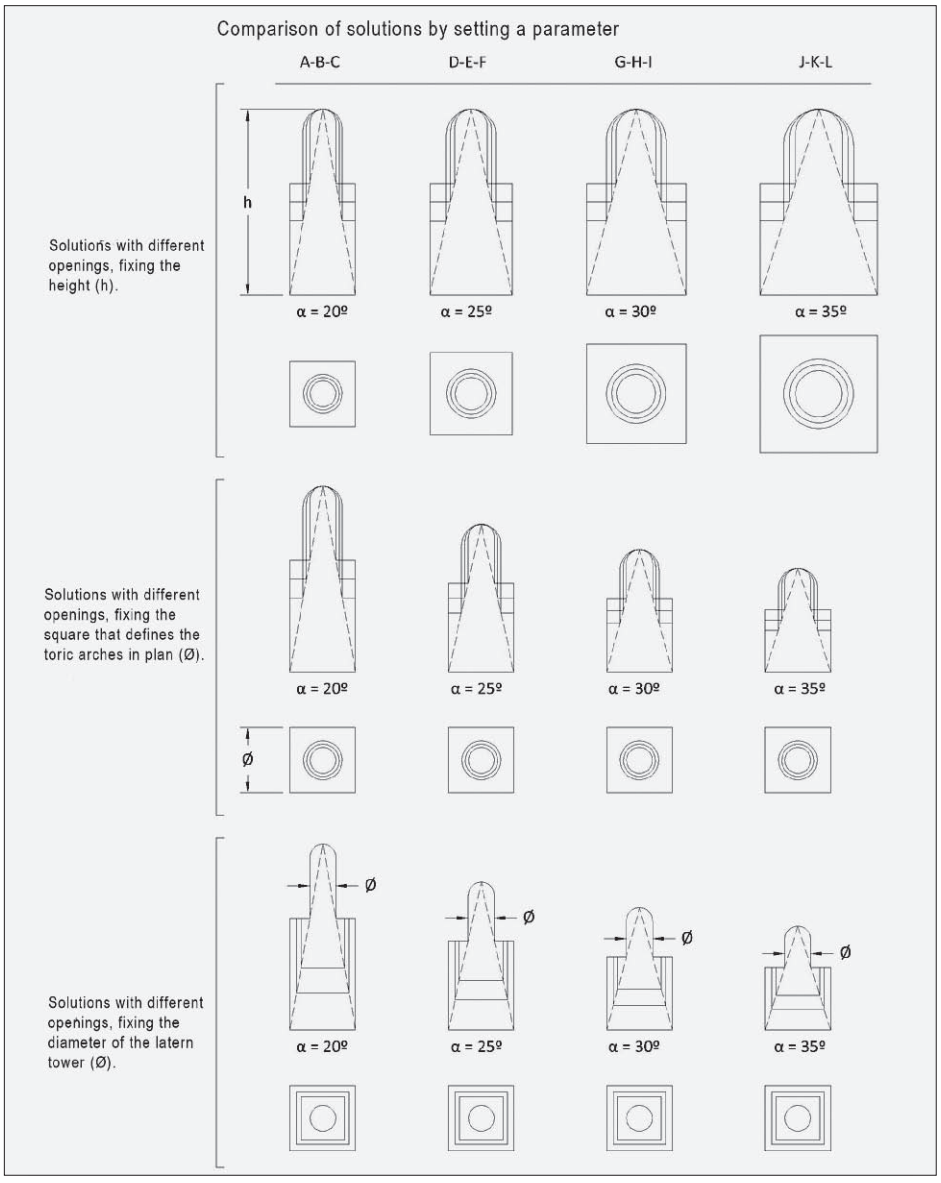


Fig. 11 Comparative tables with different solutions when a specific value is fixed

intermediate values are observed, corresponding to churches that maintain moderate and balanced proportions in terms of contrast and slenderness. For instance, this is evident in the case of B21-Govora and B26-Surpatele.

The B21-Govora church is as an example where the dimensions of the square nave closely align with the average of the churches examined, classifying it as an average-sized church. It has also been noted that the height of the lantern tower is close to the mean of the study. After calculating the Perception Coefficient *(PC)*, it can be observed that B21 is consistently well-classified in an area of intermediate values.

The church B21-Govora features a trefoil plan with a single lantern tower, avoiding excessive lanterns illuminating the narthex. It also boasts a characteristic porch supported by stone piers and arches, with a frescoed wall contrasting the facade's whiteness. The horizontal impost runs throughout the entire structure without any vertical breaks, suggesting it is an original rather than a later addition.

The B21-Govora church has a smaller-scaled narthex and a massive wall towards the nave. Notably, the narthex has a harmoniously proportioned plan. The nave is covered with a classic succession of arcs and vaults. The lantern tower lacks reductive elements, confirm-

ing its diameter as the length of the separation between piers.

In summary, everything about the Govora monastery church places it as one of the paradigmatic examples of Orthodox architecture in Wallachia. It is a church that maintains the most characteristic patterns and ideal proportions for the symbolism of its parts and can be seen as the materialization of a canon.

The example is not conclusive, since the division does not always occur in the middle height. The diversity of variants of the isosceles triangle inscribed in the longitudinal section gives a great diversity of possible solutions.

The low angle visual *(Lav)* is the edge of the triangle that passes through three points (zenith, keystone of the arc, and limit of the nave) and can take any inclination depending on the opening of the nave's cone. If a parameterization is performed of these concepts 2 unknowns appear: aperture angle *(a)* and height of the dome *(h)*, from the arc key to the zenith.

The opening angles of the cone of the nave oscillate between 17° of B15-Dintrunlemn and the 35.7° of B22-Aninoasa. Depending on the opening of the cone *(a)* and the height of the dome *(h)*, very different proportions can be obtained for the volume of the nave.

Next, some examples are shown for different openings at 20°, 25°, 30° and 35°, in combination with different variants of the dome height. In the table, each of the 18 churches is assigned to the combination that belongs to it (Figs. 9 and 10).

In the final part, a comparison table is shown (Fig. 11) with different solutions when a specific value is fixed. This information is used to determine that, with same interior height, different sizes of the square floor plan can be obtained, and vice versa, different heights with the same floor plan. The position of toric arches becomes critical to the configuration of the entire nave. It can be concluded that the same dome diameter gives rise to multiple proportions and dimensions of the floor plan.

All are valid solutions that confirm the established pattern and, in this particular case, contradict the common belief that associates a large dome to a large-sized church.

Conclusion

The emotions and impressions felt by a believer upon entering a church can be compared to the feelings a citizen might experience when entering a public building, museum, or a hotel. Today, these sensations can be precisely measured through facial or body analysis techniques, coupled with emotion measurement sensors, as in "Exploringthe Potential of Artificial Intelligence as a Tool for Architectural Design: A Perception Study Using Gaudí's Works" (Zhang, Fort and Giménez-Mateu, 2023). Another aspect that could be considered is the analysis of light intensity in space as one of the perceptual elements of architecture. In this sense, another line of future research would be that of Professor Iakovos Potamianos, who focuses his teaching and research on issues related to the phenomenological perception of space (Jabi and Potamianos, 2016). In contrast, this text proposes measurement and classification solutions grounded in logical geometric relationships of spaces, offering a systematic approach when applied to various examples of churches.

In this case study, two key aspects are assessed. Firstly, the perception of contrast is examined, which involves the transition from a narrow space with a limited view to a spacious area with extended views. This shift – and as we have previously mentioned it may constitute a line of future research – can evoke emotions that startle and heighten the senses, as stated by Rudolf Arnheim in his work "Art and Visual Perception: A Psychology of the Creative Eye" (Arnheim and Balseiro, 2002).

Secondly, the study explores the architectural quality derived from slender proportions within enclosed spaces, characterized by a narrow base and considerable height. This slender design imparts a sense of architectural excellence, linking greater slenderness to a display of intricate construction and a clear demonstration of the author's mastery. Both of these added values, contrast, and slenderness, are objectively measurable from a geometric standpoint and contribute significantly to the classification of buildings. This becomes especially relevant when dealing with morphologically similar structures, such as the churches in Wallachia.

Finally, the cone opening angle *(a),* and the height of the dome from the keystone to the zenith *(h),* has allowed us to classify these churches, and verify optimal compliance with architectural requirements.

The article demonstrates that, based on measurable and objective variables, buildings can be systematically organized, shedding light on which ones leave a greater or lesser impression on the visitor. These parameters can be adapted to novel architectural endeavours across diverse fields, fostering the creation of more immersive and emotionally resonant architectural experiences.

In essence, this research pioneers a vision for the future of architecture, emphasizing a design philosophy where the configuration of spaces goes beyond mere functionality, aiming to create emotionally memorable and meaningful architectural structures.

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Sources of illustrations

Figs. 1, 5, 10, 11a,b,c	Provenance, authors
Fig. 2	Ghika-Budesti, 1936
Figs. 3, 4, 7-9	Giménez-Mateu, 2016
Fig. 6	Ousterhout, 1999: 81 (original from N.K. Moutsopoulos)

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