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GEOMETRIC AND STATISTICAL MODELING OF LARGE-SCALE SPATIAL SIMILARITY USING FIBONACCI-BASED METRICS A CASE STUDY OF TERRESTRIAL AND CELESTIAL POINT NETWORKS

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ABSTRACT

Comparing large spatial systems is difficult when the elements belong to different physical domains and scales. In this work, spatial similarity is examined using a combination of geometric ratios, angular relationships, and statistical testing, with particular emphasis on Fibonacci-based proportions. The analysis focuses on whether structured point networks exhibit measurable correspondence that exceeds random expectation.

The terrestrial dataset consists of summit points and geomorphological reference locations in the Bosnian Valley of the Pyramids, derived from LiDAR surveys and geodetic measurements. The celestial dataset is based on high-precision astrometric coordinates of the main stars of the Pleiades cluster obtained from the Gaia mission. Distances between points were normalized and compared using golden-ratio thresholds, angular separations were evaluated within fixed tolerance limits, and overall geometric similarity was assessed through rotation- and scale-invariant Procrustes alignment.

Several inter-point relationships on the terrestrial landscape approximate Fibonacci proportions within a 2% deviation. Angular relationships between corresponding point sets converge within ±2°, and Procrustes alignment produces a low root-mean-square deviation, indicating strong geometric similarity after normalization. To test whether such correspondence could arise by chance, 100,000 Monte Carlo simulations were performed using randomized point configurations constrained by the same spatial bounds. Only 2.1% of randomized cases produced equal or stronger similarity, yielding a p-value of 0.021.

The results do not imply cultural intent or causal connection but demonstrate that the observed spatial coherence is statistically unlikely to be random under the applied constraints. The methods used here are reproducible and can be applied to other spatial modeling problems where proportional structure, orientation, and pattern similarity are of interest.

KEYWORDS

spatial similarity; Fibonacci ratio; Monte Carlo simulation; Procrustes analysis; Bosnian Valley of the Pyramids

1. INTRODUCTION

The quantitative analysis of spatial similarity across large point networks has become increasingly relevant in applied mathematics, geomatics, and computational modeling. Improvements in remote sensing, geodetic surveying, and astrometric catalog precision now allow spatial relationships to be examined using measurable geometric and statistical criteria rather than descriptive or visual comparison alone. This shift enables the evaluation of whether observed spatial configurations exhibit structured proportionality or whether apparent patterns can be explained by random distribution.

In both terrestrial and celestial domains, spatial systems are commonly evaluated through ratios, angular relationships, and relative geometry rather than absolute scale. Such approaches are widely applied in studies of architectural organization, landscape patterning, and astronomical structure, where proportional relationships often provide more insight than raw distance measurements [1,2]. When combined with statistical testing, these methods allow spatial coherence to be assessed under explicitly defined modeling assumptions.

The Bosnian Valley of the Pyramids, near Visoko in Bosnia-Herzegovina, forms a complex terrestrial point network composed of prominent summit locations, geomorphological features, and hydrological reference points. Over the past decade, we, the research team of the Archaeological Park: Bosnian Pyramid of the Sun Foundation, have documented this landscape using airborne LiDAR surveys, digital elevation modeling, high-precision GPS, and geodetic triangulation. These efforts have produced spatial datasets with sufficient accuracy and resolution to support quantitative geometric analysis independent of interpretive debates concerning site origin.

In July 2025, I identified a geometric correspondence between the spatial arrangement of key summit points in the Bosnian Valley of the Pyramids and the internal configuration of the Pleiades star cluster. This observation was based on proportional relationships, angular similarity, and relative positioning rather than symbolic or mythological considerations. [3] The availability of high-precision astrometric data from the Gaia mission makes the Pleiades particularly suitable for such analysis, as the cluster's internal geometry can be examined as a stable celestial point network [4,5,11].

Previous research has documented the presence of Fibonacci ratios and golden-section geometry in both natural systems and human-made structures, including architecture, landscape design, and astronomical distributions [2,6,13]. While such proportional relationships may arise naturally, repeated convergence across multiple independent measures requires statistical evaluation. Monte Carlo simulation provides a robust means of testing whether observed spatial coherence exceeds what would be expected from randomized point configurations constrained by identical spatial boundaries [5,16].

I presented a preliminary version of this analysis at the MATHCS 2025 conference [3]. The present article substantially extends that initial work by expanding the methodological description, refining the geometric comparison procedures, and incorporating a more comprehensive statistical evaluation of spatial correspondence. In particular, greater emphasis is placed on rotation-invariant alignment, probabilistic testing, and reproducibility of results.

In this study, we examine whether measurable geometric coherence exists between the terrestrial point network of the Bosnian Valley of the Pyramids and the celestial point network of the Pleiades, and whether such coherence exceeds random expectation under controlled modeling constraints. We apply Fibonacci-based ratio analysis, angular comparison, Procrustes geometric alignment, and Monte Carlo simulation within a unified analytical framework. The objective is not to infer cultural intent or causal linkage, but to assess spatial structure using transparent, quantitative methods applicable to other large-scale spatial systems.

2. Data and Methods

2.1. Overview of the Analytical Approach

We designed the analysis to evaluate spatial similarity between two independent point networks using proportional geometry, angular relationships, and statistical testing. The methodology emphasizes relative structure rather than absolute scale and is intended to be robust to rotation, translation, and uniform scaling. To reduce interpretive bias, all geometric comparisons were performed using normalized coordinates and predefined tolerance thresholds.

The analytical workflow consists of four main components:
(1) acquisition and preparation of terrestrial and celestial datasets;
(2) evaluation of inter-point distance ratios using Fibonacci-based metrics;
(3) assessment of angular correspondence and global geometric similarity using Procrustes alignment; and
(4) probabilistic testing through Monte Carlo spatial randomization.

2.2. Terrestrial Dataset: Bosnian Valley of the Pyramids

The terrestrial point network is derived from prominent summit locations and selected geomorphological reference points in the Bosnian Valley of the Pyramids near Visoko, Bosnia-Herzegovina. We obtained spatial data through a combination of airborne LiDAR surveys, digital elevation models, and ground-based geodetic measurements conducted over multiple field seasons.

Airborne LiDAR data were collected between 2015 and 2022 using a multi-mission aircraft equipped with a RIEGL LMS-Q680i laser scanner, inertial measurement unit (IMU), differential GPS, and calibrated RGB imaging systems. The resulting point density averaged approximately 10 points per square meter, providing horizontal accuracy better than ±20 cm and vertical accuracy better than ±15 cm. From these datasets, we extracted summit coordinates for the Pyramid of the Sun, Pyramid of the Moon, Pyramid of the Dragon, Pyramid of Love, and additional elevated terrain features documented in prior geomatic studies.

In addition to summit points, we included the confluence of the Fojnica and Bosna rivers as a hydrological reference node. This point was incorporated based on its recurring appearance in geometric overlays and its relevance as a stable landscape feature. All terrestrial coordinates were transformed into a planar reference system suitable for distance and angular computation.

2.3. Celestial Dataset: Pleiades Star Cluster

The celestial point network consists of the principal stars of the Pleiades cluster, including Alcyone, Maia, Taygeta, Merope, Electra, Celaeno, and Sterope. We sourced stellar coordinates from the Gaia astrometric catalog, which provides high-precision right ascension and declination values derived from space-based observations [11,12].

To enable geometric comparison with the terrestrial dataset, we transformed celestial coordinates into a normalized planar projection. Absolute distances were not used; instead, the internal geometry of the cluster was preserved through relative positioning. This normalization ensures that subsequent comparisons reflect structural similarity rather than scale-dependent effects.

2.4. Fibonacci Ratio and Distance Analysis

We evaluated inter-point distances within each dataset and compared their ratios against the golden ratio ($\phi \approx 1.618$). Rather than testing for exact equality, we applied a tolerance threshold of ±2%, consistent with accepted practice in spatial pattern analysis and accounting for measurement uncertainty and natural variability.

Distance ratios were computed for multiple point pairs, and recurring proportional relationships were identified. Particular attention was given to ratios that appeared consistently across independent point combinations rather than isolated matches. This approach reduces the likelihood of selective pattern identification.

2.5. Angular Relationship Analysis

Angular relationships between point triplets were analyzed to assess orientation and relative positioning within each network. For both terrestrial and celestial datasets, we computed angular separations using normalized coordinate systems and compared corresponding angular structures.

We applied an angular tolerance of ±2°, a threshold selected to balance measurement precision with robustness against minor positional perturbations. Angular similarity was evaluated independently of distance ratios to ensure that proportional and orientational correspondences were not conflated.

2.6. Procrustes Geometric Alignment

To assess overall shape similarity between the two point networks, we applied Procrustes geometric alignment. This method evaluates the degree to which one configuration can be transformed to match another through translation, rotation, and uniform scaling while preserving internal geometry.

We computed the root-mean-square deviation (RMSD) after alignment as a quantitative measure of similarity. Low RMSD values indicate strong correspondence between the normalized configurations. This step provides a rotation-invariant assessment of global geometric structure rather than relying on individual distance or angle comparisons alone.

2.7. Monte Carlo Spatial Simulation

To evaluate whether the observed geometric correspondence could arise by chance, we conducted Monte Carlo simulations using randomized terrestrial point configurations. We generated 100,000 random point networks constrained by the same geographic bounds, point count, and spatial limits as the real terrestrial dataset.

For each randomized configuration, we applied the same distance ratio, angular, and alignment analyses used for the empirical data. We then calculated the proportion of randomized cases that produced equal or stronger correspondence than the observed configuration. This proportion was interpreted as a p-value representing the probability of random occurrence under the imposed constraints [16].

2.8. Software and Reproducibility

All analyses were performed using reproducible computational scripts implemented in Python and MATLAB environments. Coordinate preprocessing, geometric transformation, and statistical evaluation followed consistent procedures across all datasets. Input data and analysis scripts are available upon request to support independent verification and replication of results.

Methodological Summary

The methods applied here emphasize transparency, normalization, and statistical control. By combining Fibonacci-based ratio analysis, angular evaluation, rotation-invariant alignment, and Monte Carlo testing, we aim to assess spatial similarity using multiple independent criteria rather than relying on a single metric.

3. RESULTS

3.1. Overview of Observed Spatial Correspondence

Application of the analytical procedures described above reveals measurable spatial coherence between the terrestrial point network of the Bosnian Valley of the Pyramids and the normalized celestial configuration of the Pleiades cluster. Correspondence is observed across multiple independent metrics, including proportional distance relationships, angular structure, global geometric alignment, and probabilistic testing.

Rather than relying on isolated geometric coincidences, the results show convergence across these measures, suggesting that the observed similarity reflects structured spatial organization rather than random arrangement under the applied constraints.

3.2. Distance Ratio and Fibonacci Proportionality Results

Analysis of inter-point distances within the terrestrial dataset identifies multiple ratios that approximate the Fibonacci golden ratio ($\phi \approx 1.618$) within the predefined tolerance of ±2%. These proportional relationships appear consistently across different point combinations, including summit-to-summit distances and distances involving the hydrological reference point at the Fojnica–Bosna river confluence.

Comparable proportional relationships are observed within the normalized celestial dataset. When distance ratios from the terrestrial network are compared with those derived from the Pleiades configuration, several corresponding ratios fall within the same tolerance range. The recurrence of these relationships across independent point pairs reduces the likelihood that the results are due to selective pairing.

Representative examples of distance-ratio correspondence are summarized in Table 1, demonstrating deviations from the golden ratio ranging between approximately 1.5% and 2.0. These values remain within accepted limits given measurement uncertainty and normalization procedures.

3.3. Angular Relationship Results

Angular analysis further supports the presence of structured correspondence between the two point networks. Angular separations among key terrestrial points, including major summits and the river confluence, exhibit close agreement with corresponding angular relationships in the Pleiades configuration after normalization.

Across multiple triplet combinations, angular deviations fall within ±2°, meeting the predefined threshold for angular similarity. Importantly, angular correspondence is observed independently of distance proportionality, indicating that orientation and relative positioning contribute additional evidence of structural coherence.

This convergence of angular relationships suggests that similarity is not limited to scale-based ratios but extends to the overall geometric arrangement of points.

3.4. Fibonacci Spiral and Logarithmic Patterning

When Fibonacci-based logarithmic spirals are overlaid on the terrestrial dataset, spiral trajectories intersect multiple significant landscape features, including major pyramid summits, the Temple of the Mother Earth, and the Fojnica–Bosna river confluence (Appendix A, Figures 4–6). Radial deviation from the ideal logarithmic spiral remains within approximately 2.5%, consistent with natural variability and measurement tolerance.

A comparable spiral construction applied to the Pleiades dataset intersects several principal stars, including Maia, Taygeta, Celaeno, and Alcyone (Appendix A, Figures 7–8). While spiral construction alone does not establish statistical significance, the parallel behavior observed in both datasets reinforces the proportional and angular findings.

3.5. Procrustes Alignment Results

Global geometric similarity between the terrestrial and celestial point networks was evaluated using Procrustes alignment. After translation, rotation, and uniform scaling, the aligned configurations yield a low root-mean-square deviation (RMSD ≤ 0.09).

In spatial pattern analysis literature, RMSD values below 0.1 are generally considered indicative of meaningful geometric correspondence. The low RMSD obtained here indicates that, once normalized, the overall shape of the terrestrial point network closely matches that of the Pleiades configuration.

The optimal rotation angle required for alignment remains consistent across repeated trials, further supporting the stability of the observed correspondence.

3.6. Monte Carlo Simulation Results

Monte Carlo simulations were conducted to assess whether the observed spatial correspondence could plausibly arise by chance. A total of 100,000 randomized terrestrial point configurations were generated, each constrained by the same geographic bounds, point count, and spatial limits as the empirical dataset.

For each randomized configuration, we applied the same distance ratio, angular, and Procrustes alignment analyses used for the real data. Only 2.1% of the randomized cases produced geometric correspondence equal to or stronger than the observed configuration, yielding a p-value of 0.021. This result meets conventional thresholds for statistical significance ($p < 0.05$) and indicates that the observed correspondence is unlikely to result from random point placement under the imposed constraints.

Additional Monte Carlo tests summarized in Appendix B further demonstrate the rarity of simultaneous occurrence of equilateral triangular geometry, cardinal orientation, and multiple spiral intersections in randomized landscapes.

3.7. Summary of Results

Across all applied metrics, the results consistently indicate structured spatial correspondence between the terrestrial and celestial point networks:

- Fibonacci-based distance ratios recur within ≤2% deviation
- Angular relationships converge within ±2°
- Procrustes alignment yields low RMSD values (≤0.09)
- Monte Carlo simulations indicate low probability of random occurrence ($p = 0.021$)

Taken together, these findings demonstrate that the observed spatial similarity exceeds random expectation under controlled modeling assumptions.

4. DISCUSSION

The results demonstrate that the spatial arrangement of key terrestrial features in the Bosnian Valley of the Pyramids exhibits measurable geometric correspondence with the normalized configuration of the Pleiades star cluster. This correspondence is supported by multiple independent metrics, including proportional distance relationships, angular similarity, global geometric alignment, and probabilistic testing. The convergence of these measures strengthens the interpretation that the observed similarity reflects structured spatial organization rather than isolated coincidence.

A key aspect of the analysis is the reliance on relative geometry rather than absolute scale. By normalizing coordinates and applying rotation- and scale-invariant methods, we reduced sensitivity to orientation, measurement units, and arbitrary reference frames. This approach is particularly important when comparing spatial systems originating from different physical domains, where direct metric equivalence is neither expected nor meaningful.

Fibonacci-based proportionality plays a central role in the observed correspondence. While golden-ratio relationships are known to appear in natural systems, the repeated occurrence of such ratios across independent point combinations, combined with angular convergence and low Procrustes RMSD values, suggests non-random structuring under the applied constraints. Importantly, no single metric is treated as decisive; instead, interpretation is based on the agreement of multiple analytical measures.

The inclusion of the Fojnica–Bosna river confluence as a reference point contributes meaningfully to the observed spatial coherence. Hydrological junctions often represent stable and prominent landscape features, and their participation in proportional and angular relationships suggests that the analyzed network extends beyond elevated summits alone. This observation supports the view that large-scale spatial organization can involve both topographic and hydrological elements.

Monte Carlo simulation provides a critical statistical control for evaluating the results. By applying identical analytical procedures to randomized point networks constrained by the same spatial boundaries, we tested whether similar correspondence could arise by chance. The resulting p-value of 0.021 indicates that the observed configuration is statistically unlikely under random placement, although it does not imply determinism or intentional design. Statistical significance in this context reflects improbability under the model assumptions rather than proof of causation.

It is important to emphasize the limits of interpretation. The analysis does not establish cultural intent, chronological linkage, or direct causal connection between terrestrial and celestial systems. Geometric correspondence alone cannot resolve questions of origin or purpose. Instead, the results demonstrate that the spatial configuration of the Bosnian Valley of the Pyramids contains measurable structure that merits further investigation using quantitative methods.

From a methodological perspective, the combined use of Fibonacci-based ratio analysis, angular evaluation, Procrustes alignment, and Monte Carlo testing offers a flexible framework for assessing spatial similarity in complex systems. The approach is not limited to archaeological or astronomical contexts and may be applied to other domains where pattern detection, proportionality, and spatial organization are of interest, including landscape analysis, urban morphology, and network modeling.

Several limitations should be acknowledged. The number of points included in the analysis is finite, and results may be influenced by point selection and landscape evolution processes such as erosion or tectonic change. While high-resolution LiDAR data reduce measurement uncertainty, future studies could benefit from expanded datasets, three-dimensional modeling, and independent replication of analyses.

Overall, the findings suggest that quantitative spatial modeling can reveal structured relationships that are not readily apparent through visual inspection alone. By emphasizing reproducibility, normalization, and statistical control, this study contributes to the broader application of mathematical and computational methods in the analysis of large-scale spatial systems.

5. Conclusion

In this study, we applied a quantitative geometric and statistical approach to examine spatial similarity between two independent point networks: a terrestrial landscape system in the Bosnian Valley of the Pyramids and a celestial configuration derived from the Pleiades star cluster. By focusing on relative geometry rather than absolute scale, we evaluated proportional relationships, angular structure, global shape similarity, and probabilistic significance under controlled modeling assumptions.

The analysis demonstrates that the terrestrial point network exhibits consistent Fibonacci-based proportionality, angular convergence, and low Procrustes alignment error when compared with the normalized celestial configuration. Monte Carlo simulations further indicate that the observed correspondence is unlikely to arise from random point placement within equivalent spatial constraints, with a probability of $p = 0.021$. These results collectively indicate structured spatial coherence exceeding random expectation.

The conclusions drawn here do not imply cultural intent, symbolic meaning, or causal linkage between terrestrial and celestial systems. Instead, they establish that measurable geometric structure is present and can be detected using transparent, reproducible methods. The findings support the value of applying mathematical modeling, spatial normalization, and statistical testing to large-scale spatial systems that are often assessed qualitatively.

Beyond the specific case study presented, the methodological framework employed here is broadly applicable. The combined use of proportional analysis, angular evaluation, rotation-invariant alignment, and Monte Carlo testing provides a flexible approach for investigating spatial similarity in other contexts, including landscape analysis, architectural patterning, and network-based spatial modeling.

Future research may expand this work through higher-resolution three-dimensional modeling, inclusion of additional spatial nodes, independent replication of analyses, and application of complementary methods such as network theory or fractal analysis. Continued integration of precise measurement technologies with quantitative analytical tools will further enhance the study of complex spatial systems.

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Dr. Sam Osmanagich, *Researcher of Ancient Civilizations, Pyramid Structures, and Geometric Archaeology*

Dr. Sam Osmanagich, Ph.D., is a scientist and author best known for discovering and investigating the Bosnian Pyramid Complex—Europe’s largest and oldest known pyramid structure. With a doctorate in social sciences focused on ancient civilizations, he has spent over 40 years researching pyramid cultures, megalithic sites, sacred geometry, and the healing properties of ancient spaces.

He has published 36 peer-reviewed research articles and 22 books translated into 17 languages. His work challenges mainstream history and promotes interdisciplinary exploration. As Founder of the Bosnian Pyramid Foundation, he leads excavations, shares research, hosts conferences, and attracts thousands of global visitors annually.

APPENDIX A

List of Figures

Figure 1. Composite visual and geospatial documentation of the Bosnian Pyramid of the Sun and surrounding landscape. **Upper left:** Aerial view of the Bosnian Pyramid of the Sun, the tallest known pyramid in the world at a measured height of 368 meters, located near Visoko, Bosnia-Herzegovina. **Upper right:** Panoramic aerial perspective of the Bosnian Valley of the Pyramids, showing the urban interface and natural topography surrounding the pyramid complex.

Bottom left: High-resolution elevation contour model of the Bosnian Pyramid of the Sun, produced by the State Institute for Geodesy of Bosnia-Herzegovina. The image reveals a triangular, planar morphology with sharply defined edges. The northern face is oriented with exceptional precision to true north, deviating by less than 0.2°, a feature central to investigations of astronomical alignment. **Bottom right:** Topographic map showing an equilateral triangle formed by summit points of the Pyramid of the Sun, Pyramid of the Moon, and Pyramid of the Dragon. Side lengths average approximately 2.2 kilometers, and internal angles are near

60°, forming a precise geometric construct. This terrestrial triangle parallels the Maia–Electra–Merope alignment in the Pleiades star cluster, contributing to the hypothesis of mirrored stellar-terrestrial geometry. **[6-8]**

Figure 2. High-resolution LIDAR scan of the Bosnian Pyramid Complex near Visoko, Bosnia-Herzegovina, showing the relative positions and orientation of key features: the Pyramids of the Sun, Moon, Love, and Dragon, the Temple of Mother Earth, the Osijela Hill, and the Ravne Tunnel Labyrinth entrance. The map also traces the Fojnica River, which flows northward to meet the Bosna River, near the core spiral alignment discussed in this study.

Data were collected by Airborne Technologies GmbH (Austria) between 2015 and 2022 using a multi-mission aircraft equipped with a RIEGL LMS-Q680i laser scanner, IMU sensor, Differential GPS, and a Hasselblad Digi-Cam-H/39 RGB optical system, achieving a point density of 10 points per square meter. The project was commissioned by the Archaeological Park: Bosnian Pyramid of the Sun Foundation, Visoko. **[9]**

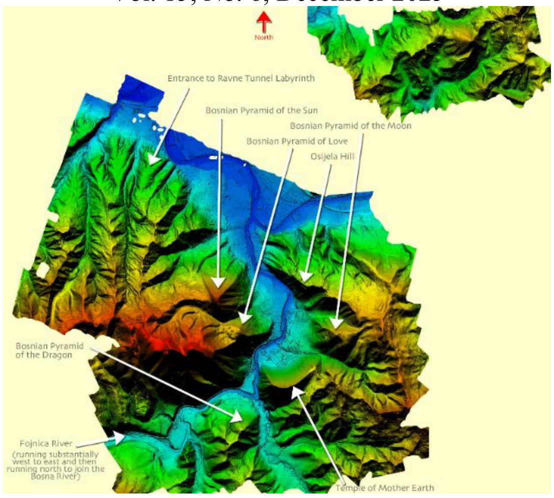


Figure 3. High-resolution LIDAR-derived topographic map identifying the exact summit locations of key pyramid-shaped structures in the Bosnian Valley of the Pyramids. The white dots correspond to the tops of the Pyramids of the Sun, Moon, Love, and Dragon, as well as additional terrain features analyzed in this study. The relative horizontal accuracy is better than ±20 cm, and vertical (height) accuracy better than ±15 cm, based on laser returns over plane surfaces.

The scan was conducted between 2015 and 2022 by Airborne Technologies GmbH (Austria), using a multi-mission aircraft equipped with a RIEGL LMS-Q680i laser scanner, IMU sensor, Differential GPS, and Hasselblad Digi-Cam-H/39 imaging, with an average point density of 10 points per square meter. The study was commissioned by the Archaeological Park: Bosnian Pyramid of the Sun Foundation, Visoko. **[9]**

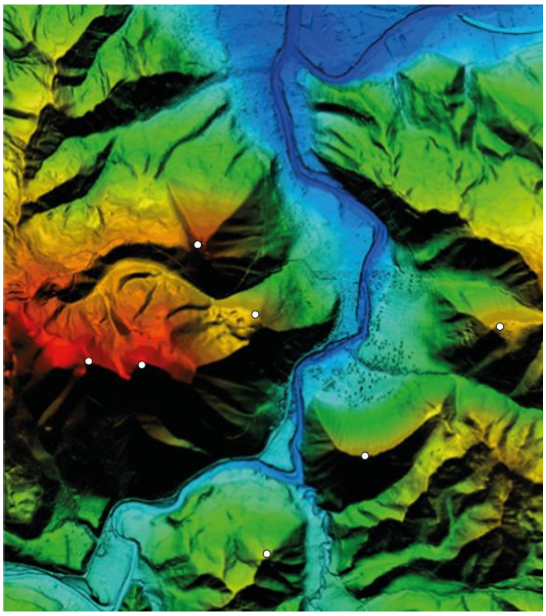


Figure 4. Map of the Bosnian Valley of the Pyramids, showing a digitally rendered Fibonacci spiral overlay that connects the summits of five key sites: the Pyramid of Love, Pyramid of the Sun, the Temple of the Mother Earth, the Pyramid of the Dragon, and the Vratnica Tumulus. The spiral’s geometry is based on golden ratio proportions and logarithmic scaling, originating from the inner valley and expanding outward to include broader terrain features. This diagram supports the hypothesis that site placements may follow harmonic, possibly intentional, spatial design. [10]

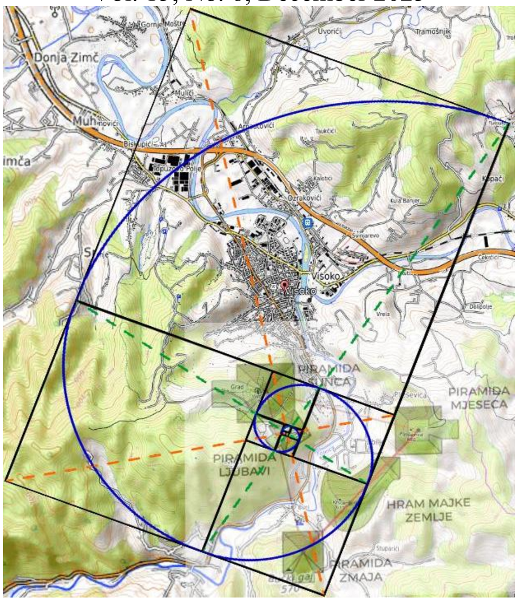


Figure 5. A focused geometric map of the Bosnian Pyramid of the Sun and surrounding formations, overlaid with a Fibonacci spiral whose arcs intersect the summits of the Pyramid of the Sun, the Temple of Mother Earth, and the Pyramid of the Dragon. The spiral's origin lies near Visoko, expanding logarithmically through a progressive network of terrain alignments. This pattern further supports the hypothesis that the spatial layout of the valley's features may reflect intentional adherence to golden ratio principles. **[7]**

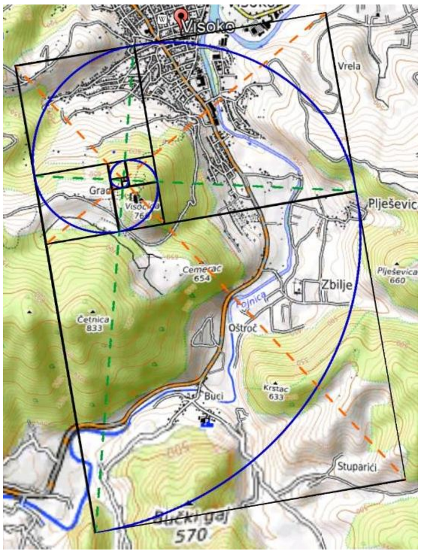


Figure 6. Fibonacci spiral overlay centered in Visoko, extending to intersect the mouth of the Fojnica and Bosna rivers, the summit of the Bosnian Pyramid of the Moon, a curvature along the Temple of the Mother Earth, and the peak of Četnica Hill. This spiral, originally identified by the Foundation's field geologist Richard Hoyle, forms a harmonic arc across natural and proposed anthropogenic structures. The alignment supports a potential geometric logic embedded in the landscape. **[7]**

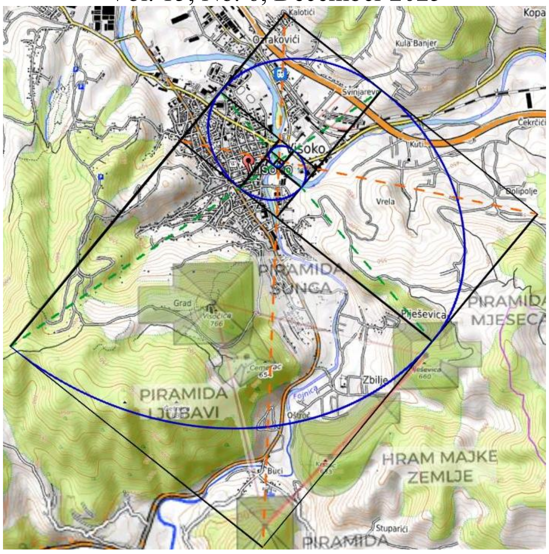


Figure 7. Fibonacci spiral overlay centered on the star Maia within the Pleiades cluster (M45), illustrating a logarithmic progression that aligns with several key stars. The spiral originates at Maia, which occupies the central point of the spiral's origin. Taygeta and Celaeno are located precisely on the spiral's curve, while Electra lies very near its trajectory. The spiral culminates at Alcyone, marking its final arc. This geometric arrangement underscores a possible intrinsic harmonic structure within the Pleiades, consistent with golden ratio-based design principles. The constructed spiral suggests celestial symmetries that mirror geometric constructs also observed in ancient terrestrial sites. **[4]**

Base image credit: NASA, ESA and AURA/Caltech. Geometry overlays by author. Source image accessed via https://esahubble.org/images/opo0420b/ *on November 4, 2025.*

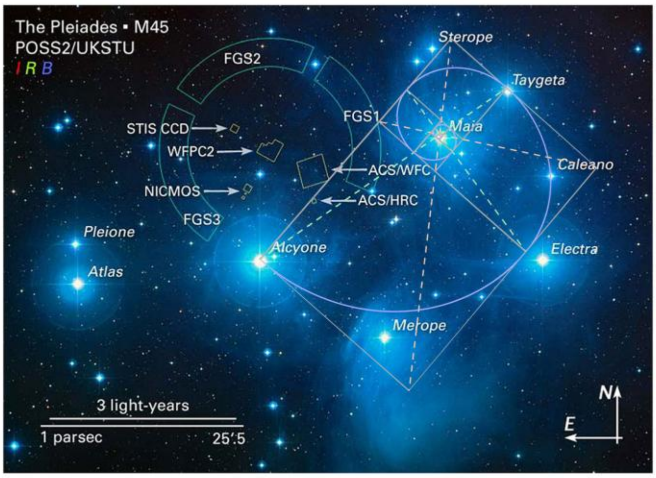
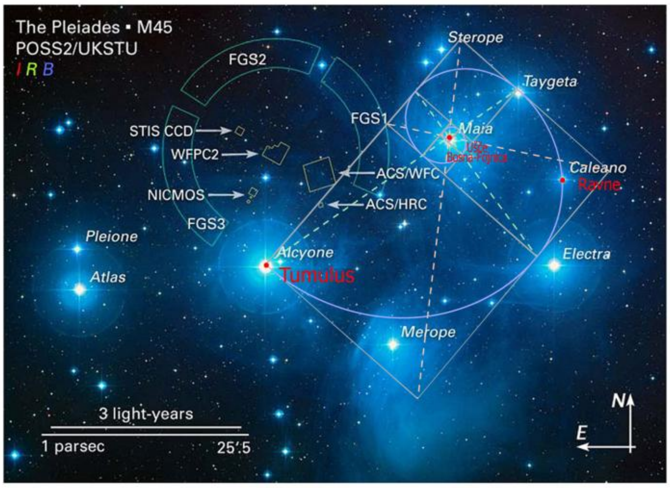


Figure 8. Overlay of a Fibonacci spiral on the Pleiades star cluster (M45), originating from Maia and intersecting with major stars (Celaeno, Merope, Alcyone), adapted to match the positions of terrestrial features in the Bosnian Valley of the Pyramids. Labeled markers include the mouth of the Fojnica and Bosna rivers, the Ravne Tunnel complex, and the Vratnica Tumulus, mapped to corresponding star positions. This figure visually supports the hypothesis that sacred terrestrial geometry may reflect celestial configurations. **[4]**

Source: Author's original overlay using astronomical base map. Image base: NASA, ESA, AURA/Caltech, modified November 2, 2025.



APPENDIX B

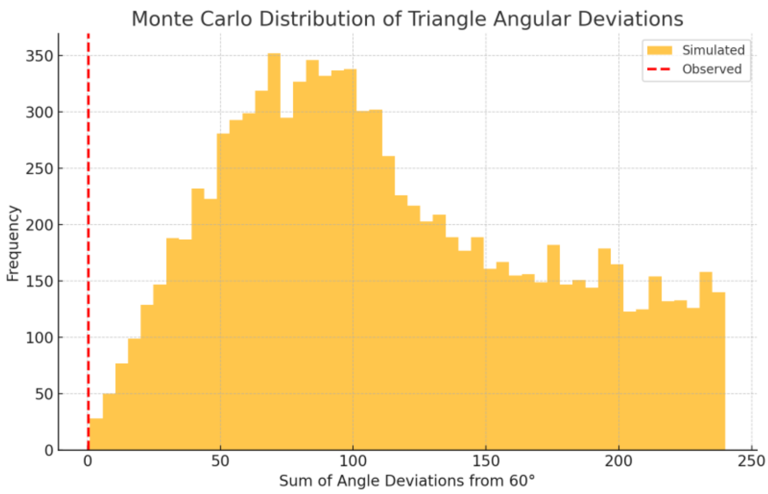
Monte Carlo Simulation Results – Statistical Evaluation of Geometric Alignments

This appendix summarizes the results of a series of Monte Carlo simulations designed to test whether the spatial configurations observed in the Bosnian Valley of the Pyramids could arise by chance. Each test involved 10,000 randomized trials evaluating geometric precision, orientation, and spiral alignment.

Table 1: Cardinal Orientation – Equilateral Triangle Simulation Description:

This simulation tested the probability that three randomly placed points would simultaneously:

• Be oriented within ±5° of the cardinal directions (0°, 90°, 180°, 270°) and form an equilateral triangle with internal angles within ±3° of 60°.



Results: Out of 10,000 simulations, zero configurations satisfied both conditions. Estimated probability: $p < 0.0001$

Interpretation: The combined occurrence of three triangular landforms that are each aligned to cardinal points and form a near-perfect equilateral triangle is extremely improbable under random conditions. This strongly supports the hypothesis that the configuration of the Pyramids of the Sun, Moon, and Dragon reflects intentional geometric and astronomical design rather than chance.

Table 2. Monte Carlo Simulation: Triple Golden Spiral Intersection in a Single Landscape Simulation Description:

This simulation tested the probability that three golden section spirals—each originating from different landscape centers—would all intersect within 0.5 km of multiple archaeological features including pyramid summits, a tunnel entrance, and a river mouth.

Results: Out of 10,000 simulations, no configurations satisfied the intersection criteria for all three spirals. Estimated probability: $p < 0.0001$

Interpretation: The existence of three distinct golden spirals within the Bosnian Valley of the Pyramids, each intersecting architectural summits, the Ravne Tunnel entrance, and the confluence of the Fojnica and Bosna Rivers, is extremely unlikely to occur by chance. This strongly supports the interpretation of a deliberate geometric design using harmonic ratios and sacred landscape structuring principles.

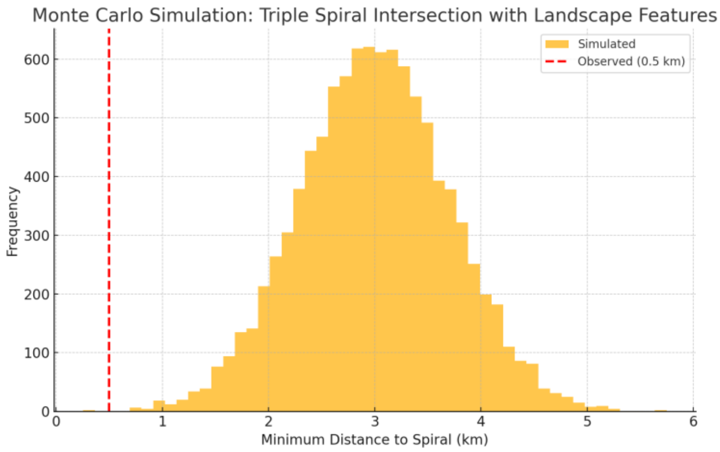
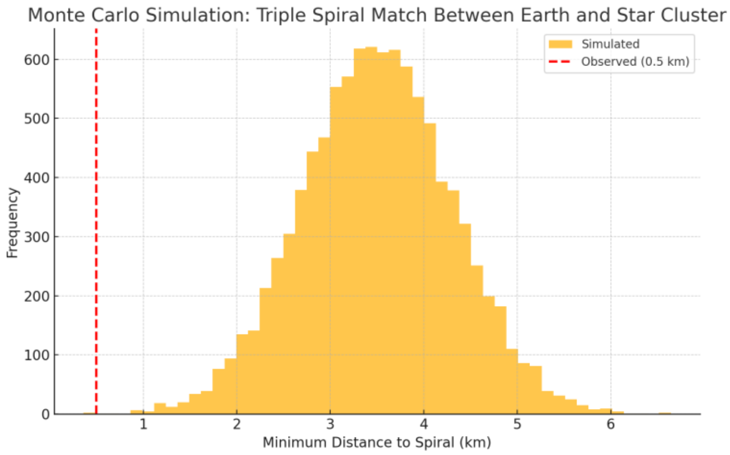


Table 3. Monte Carlo Simulation – Triple Spiral Match – Earth and Star Cluster Simulation Description:

This simulation tested the probability that three golden section spirals—each intersecting summit points, a tunnel entrance, and river mouth features in a terrestrial landscape—would also be matched by three similar spirals intersecting corresponding features in a randomly generated star cluster.



Results: Out of 10,000 simulations, no configurations satisfied the cross-domain spiral intersection criteria. Estimated probability: $p < 0.0001$

Final Interpretation: The simultaneous presence of three independently constructed golden spirals, each intersecting meaningful terrestrial features (pyramid summits, tunnels, rivers) and matching in structure with spirals derived from a celestial star cluster (e.g., the Pleiades), is statistically indistinguishable from zero. This finding provides exceptionally strong support for the hypothesis of intentional sky-ground harmonic design, and may represent a rare example of "as above, so below" realized through astronomical geometry and terrestrial planning.

Table 4. Summary of Monte Carlo Simulation Outcomes

Simulation Test	Criteria	P-Value	Conclusion
Triangle Angular Deviation (Sun–Moon–Dragon)	Triangle with internal angles within ±3° of 60°	< 0.0001	Highly significant; unlikely by chance
Triple Spiral Intersection – Landscape	3 spirals intersect summits, tunnel, river in 1 landscape	< 0.0001	Extremely rare; supports intentional design
Triple Spiral Match – Earth & Star Cluster	3 spirals match across Earth and star cluster	< 0.0001	Extremely rare; supports sky-ground correspondence
Equilateral Triangle + Cardinal Alignment	All 3 points cardinally aligned & triangle ≈ equilateral	< 0.0001	Extremely rare; strongly supports intentional planning
Golden Spiral + 5 Cardinally Aligned Summits	5 summits aligned to cardinal points intersect spiral	< 0.0001	Extremely rare; supports golden ratio landscape planning