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Research Article

True North Across Civilizations: Comparative Study of Pyramid Alignments in Five Continents

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Abstract

This study investigates the precise orientation of ancient pyramidal structures to true north across five continents. Using data from LIDAR scans, geodetic measurements, and archaeological records, we compare the cardinal alignment accuracy of major pyramids in Egypt, China, Bosnia, Sudan (Nubia), the United States, and Latin America. The Bosnian Pyramid of the Sun demonstrates a remarkable alignment-within 12 arcseconds of true north-confirmed by the Bosnian Geodetic Institute and high-resolution LIDAR analysis. Similar, though slightly less precise, orientations are observed in the Egyptian pyramids of Giza and Dahshur. Chinese pyramids, notably the Yangling Mausoleum, exhibit deliberate near-north alignment, while Nubian pyramids show consistent cardinal orientation. Monumental structures in North and Central America, such as Monks Mound at Cahokia (Illinois) and Temple I at Tikal (Guatemala), also display north-facing or astronomically calibrated orientations. The study highlights a recurring architectural phenomenon across time and space: the intentional orientation of sacred structures toward cardinal directions-especially true north-suggesting shared symbolic or astronomical priorities among diverse ancient civilizations.

Keywords: Civilizations; Pyramid; Alignments; Continents

Introduction

The alignment of monumental structures with cardinal directions-particularly true north-is a recurring feature in the architectural traditions of many ancient civilizations. From Egypt to China, from the Americas to the Balkans, builders of pyramids, mounds, and temples demonstrated a sophisticated awareness of geospatial orientation. The northward alignment, in particular, has long been associated with cosmological symbolism, solar and stellar navigation, and the anchoring of sacred space to celestial order.

This article explores the phenomenon of precise cardinal orientation in pyramidal structures across five continents, focusing on the Bosnian Pyramid of the Sun and its comparative alignment with pyramids in Egypt, China, Sudan (Nubia), the United States, and Latin America. While the Egyptian pyramids of Giza and Dahshur are celebrated for their near-perfect northward orientation, the Bosnian Pyramid of the Sun matches or even exceeds this precision, with a deviation of only 12 arcseconds from true north. Recent LIDAR data and geodetic measurements confirm the accuracy of this alignment, raising important questions about the surveying capabilities and cosmological intent of its builders [1].

Beyond the Old World, the study extends to pyramidal structures in North and Central America, including Monks Mound at Cahokia and El Castillo at Chichen Itza, some of which exhibit precise cardinal alignment, while others, like El Castilo reflect astronomical or calendrical orientations. Similarly, Chinese burial pyramids and Nubian pyramids in Sudan show strong evidence of deliberate alignment with cardinal directions or celestial bodies.

This comparative investigation draws on empirical data, archaeological reports, and geospatial surveys to examine whether these diverse cultures, separated by geography and time, shared a common principle: aligning sacred structures with the cosmos through precise orientation.

Egyptian pyramids: Mastering cardinal precision

The Great Pyramid of Egypt, also known as the Pyramid of Khufu or Cheops, stands as a monumental testament to geometric and astronomical knowledge in antiquity. It is oriented with extraordinary accuracy to true north, with a deviation of approximately 3 arcminutes (0° 0′ 3″) [2]. This precision remains one of the most remarkable architectural achievements ever documented and reflects the application of advanced observational and surveying techniques.

Other major pyramids exhibit similarly deliberate cardinal orientation:

- **Khafre (Khefren):** ~3 arcminutes
- **Menkaure (Mikerinos):** ~18 arcminutes
- **Red Pyramid (Dahshur):** ~5 arcminutes
- **Bent Pyramid (Dahshur):** ~12 arcminutes
- **Step Pyramid (Saqqara):** ~3 degrees

Researchers such as Dash [3] and Belmonte [2] have analyzed these alignments and suggested that ancient Egyptian builders employed stellar-based orientation methods. The near-uniform orientation of these structures demonstrates a clear emphasis on anchoring monumental architecture to the cardinal axis, and especially to true north, regardless of symbolic interpretation.

The Egyptian example establishes a high standard of geodetic precision that serves as a foundation for comparison with other pyramid-building cultures around the world.

Chinese pyramids: The yangling mausoleum and celestial alignment

China's ancient pyramid-like structures-particularly those in Shaanxi Province-represent a sophisticated architectural tradition that has only recently begun to receive broader scholarly attention. These large earthen platforms, shaped in a pyramidal form and often covered with vegetation, are traditionally referred to as "mausoleums" based on historical interpretation. However, their exact purpose, symbolism, and technological attributes remain open to further research.

A leading example is the Yangling structure near Xi'an, associated with the Han dynasty. Based on geodetic measurements presented at the First International Scientific Conference on the Bosnian Pyramids (Sarajevo, 2008), the structure is aligned with remarkable accuracy at 359° 32′ 25.6″, or just 27.4 arcminutes west of true north. The research was conducted by Dr. Jiao Nanfeng and Dr. Cao Fazam of the Archaeological Institute of Shaanxi Province and the Han Yangling Museum, respectively [4].

The precision of this alignment places the Yangling pyramid among the best-oriented ancient structures globally. While much is still unknown about the techniques used for orientation, or the cosmological intent behind such precision, the data strongly suggests the use of celestial references or geodetic methods. The Yangling site thus provides compelling comparative evidence alongside other precisely aligned pyramids in Bosnia and Egypt.

Bosnian pyramid of the sun: Precision and surveying mastery in visoko

The Bosnian Pyramid of the Sun, located in Visoko, Bosnia and Herzegovina, exhibits one of the most precise cardinal alignments ever recorded in ancient architecture. The northern face of the pyramid is aligned with a deviation of only 12 arcseconds from true north, surpassing even the precision of the Egyptian pyramids. This extraordinary accuracy was confirmed by geodetic surveys conducted by the Bosnian Geodetic Institute, under the direction of geodesist Enver Buza, using high-precision Total Station equipment (TS 600–Topcon) [5].

Orientation Analysis of the Bosnian Pyramid of the Sun: A detailed topographic and geodetic study of the Bosnian Pyramid of the Sun (Visočica Hill) was conducted by Enver Buza and the Geodetic Institute of Bosnia and Herzegovina between 2005 and 2007. Using rectangular coordinates (Y=6514550, X=4870291, H=767 m), and referencing the Gauss-Krüger projection (Bessel ellipsoid), the structure was analyzed for both its slope geometry and cardinal

orientation. The frontal northern face revealed an equilateral triangular shape in the ground plan, with side angles approximating 60 degrees.

The northern slope from top to bottom displayed four equidistant surface levels with consistent inclines and minor local deviations. Similar observations were made for the eastern and western sides, with erosive features of 4.5 meters on the southern and eastern faces. The western face showed plateau-like extensions which were interpreted as later additions. This precision is reflected in the orientation of the northern slope, measured using a TS 600-Topcon Total Station. The team concluded a deviation of only 12 arcseconds from true north-superior to the orientation accuracy of many well-known pyramids worldwide.

Topographic LIDAR scans conducted by Airborne Technologies GmbH (Austria) between 2015 and 2022 confirm the geometrical regularity and cardinal orientation of the Bosnian Pyramid of the Sun. These aerial laser measurements, carried out using a Multi Mission Aircraft and LMS-Q680i airborne scanner (RIEGL) with IMU and Differential GPS, achieved positional accuracy better than ±20 cm and height accuracy better than ±15 cm. With a point cloud density of 10 points per square meter and accompanying RGB and thermal imaging, the survey mapped the full structure in detail [6].

A series of visual data-orthophotos, digital terrain models (DTM), and contour illustrations-confirm the artificial nature of the pyramidal shape and its strict orientation to true north. These include multicolor elevation models that highlight the structure's

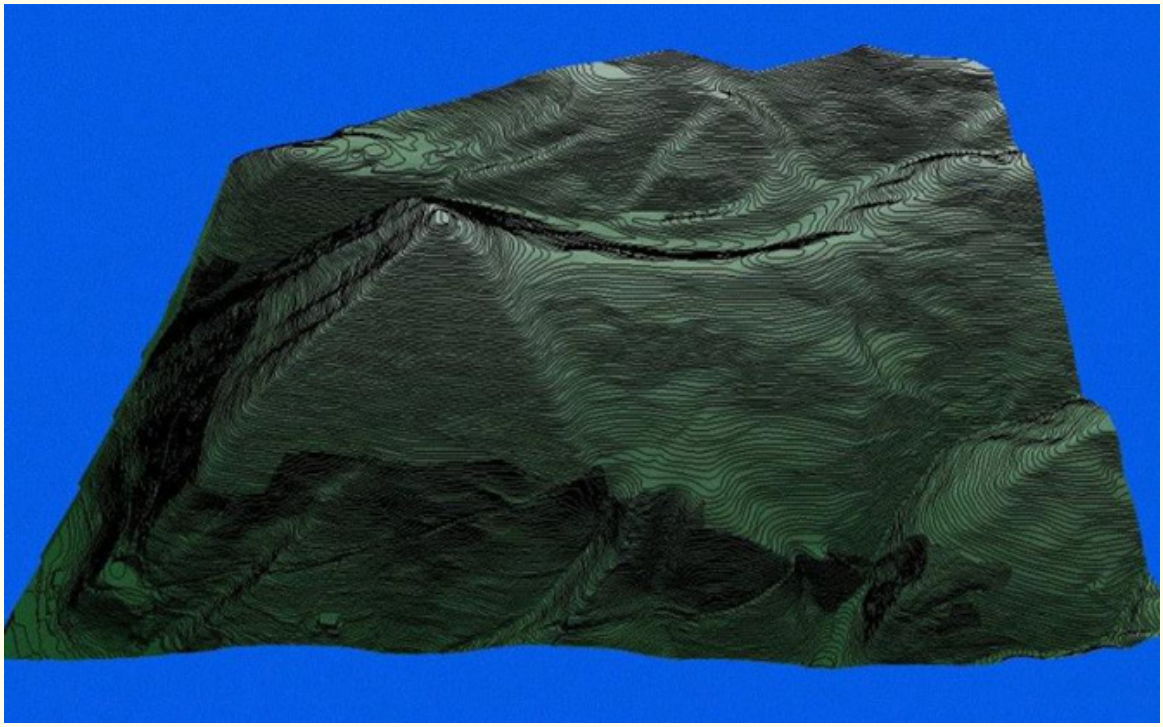

Figure 1: Topographic contour map and orientation model of the Bosnian Pyramid of the Sun.
Source: State Institute for Geodesy, Bosnia-Herzegovina, 2006. (Osmanagich, S. Bosnian Pyramids, My Story, 2023, p. 252) [7].

Figure 2: Topographic contour map showing slope symmetry and triangulation of the Bosnian Pyramid of the Sun.
Source: Eng. Enver Buza, geodesist, State Institute for Geodesy of Bosnia-Herzegovina, "The Analysis of the Landscape and Topography", ICBP Proceedings, The First International Scientific Conference on Bosnian Pyramids, Sarajevo, August 25-30, 2008, publisher 'Archaeological Park: Bosnian Pyramid of the Sun' Foundation, 2009, p. 475–478. [5].

alignment, slope regularity, and spatial geometry. The LIDAR contract and execution documents, including all calibration and sensor specifications, provide essential methodological transparency.

These findings, supported by both ground-based geodetic methods and airborne LIDAR technologies, firmly establish the Bosnian Pyramid of the Sun as one of the most accurately oriented structures ever measured.

Figure 3: Aerial photograph of the Bosnian Pyramid of the Sun in Visoko.
Source: Osmanagich, S. My Story, 2023 11. [7].

Figure 4: Map showing the location of the Bosnian Pyramid of the Sun within the wider Bosnian Valley of the Pyramids. **Source:** Osmanagich, S. My Story, 2023 252. [7].

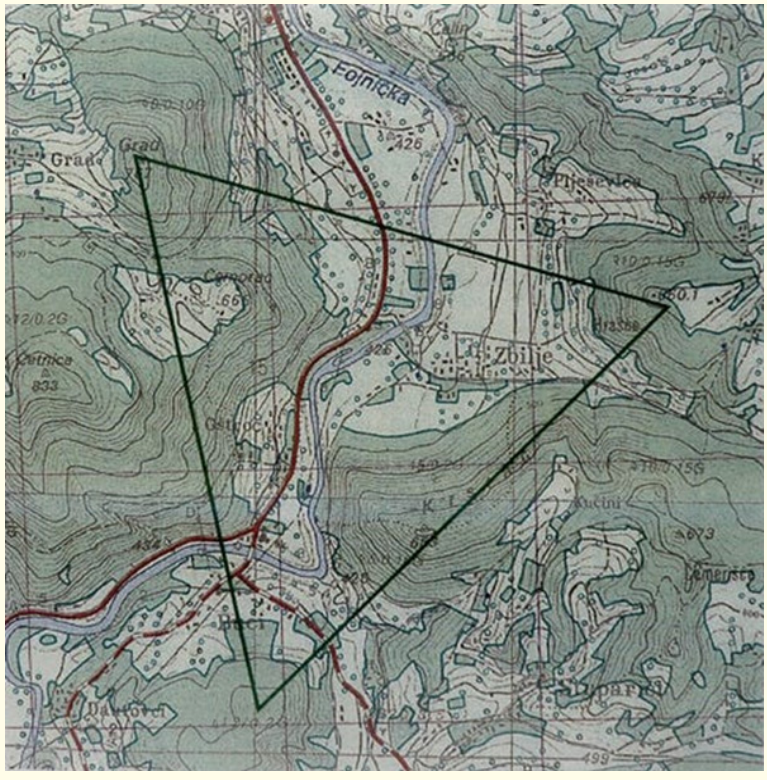

Figure 5: Triangular formation of the Pyramids of the Sun, Moon, and Dragon based on cadastral data from the Municipality of Visoko (2.2 km per side). Source: Osmanagich, S. My Story, 2023, p. 15. [7]

Further confirmation of the structure's geometry and apex location was provided through high-resolution LIDAR (Light Detection and Ranging) scans, conducted between 2015 and 2022 by the Austrian research team from Airborne Technologies GmbH. These airborne surveys used a RIEGL LMS-Q680i laser scanner, producing a 3D point cloud with positional accuracy better than ±20 cm and vertical accuracy on plane surfaces better than ±15 cm. The point density of approximately 10 points per square meter enabled precise topographical modeling of the Visoko valley, clearly outlining the edges and summit of the pyramid.

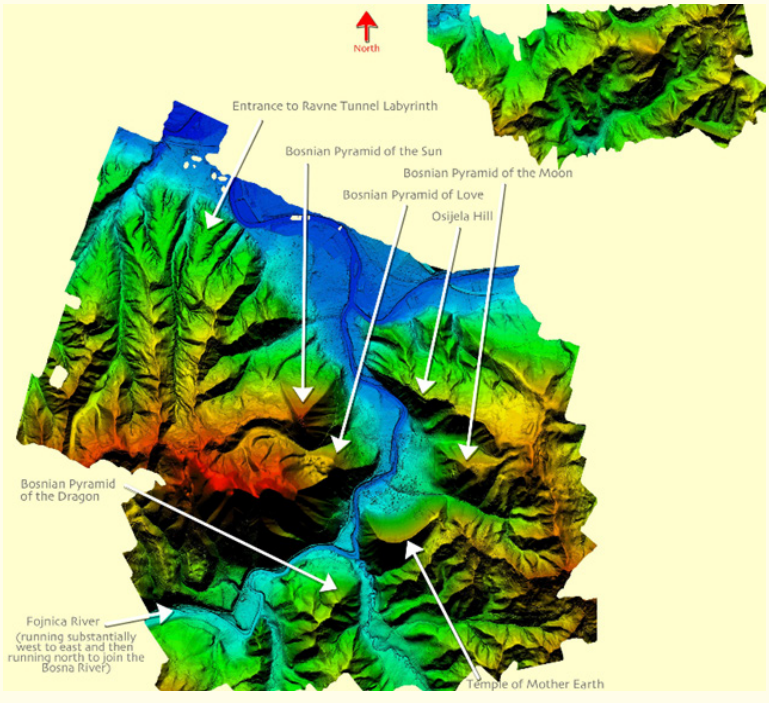

Figure 6: LIDAR scan of the Bosnian Valley of the Pyramids highlighting the Bosnian Pyramid of the Sun. Source: Airborne Technologies GmbH, 2015–2022. [6].

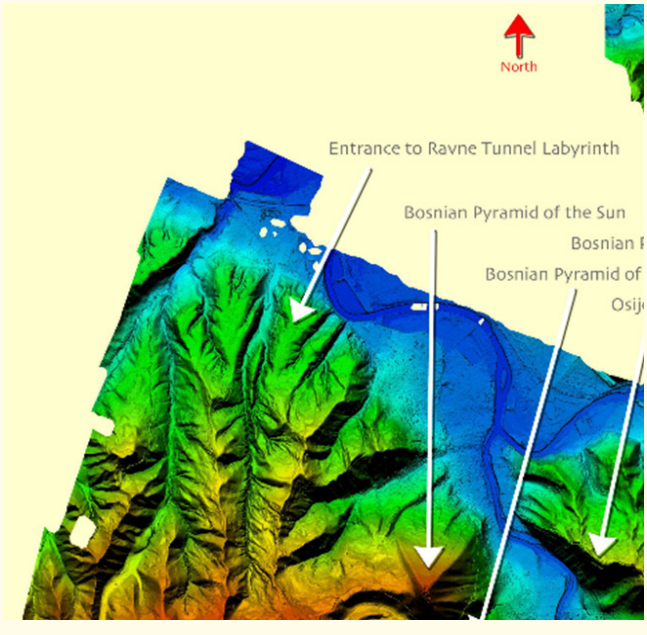

Figure 7: Orientation overlay using LIDAR data showing cardinal alignment of pyramid structures in the Visoko Valley. Source: Airborne Technologies GmbH, 2015–2022. [6].

Unlike many conventional explanations that assign ritual or funerary purposes to pyramid structures, the Bosnian Pyramid of the Sun stands out not only for its orientation but for the broader context of sacred geometry present throughout the Visoko complex. Its alignment to true north appears intentional and methodologically consistent with other observed geometric relationships, including equilateral triangles and Fibonacci spirals connecting surrounding structures.

Taken together, the geodetic, topographic, and LIDAR evidence strongly supports the conclusion that the builders of the Bosnian Pyramid of the Sun possessed advanced knowledge of orientation, geometry, and spatial planning-potentially on par with or even exceeding that of their counterparts in Egypt and China.

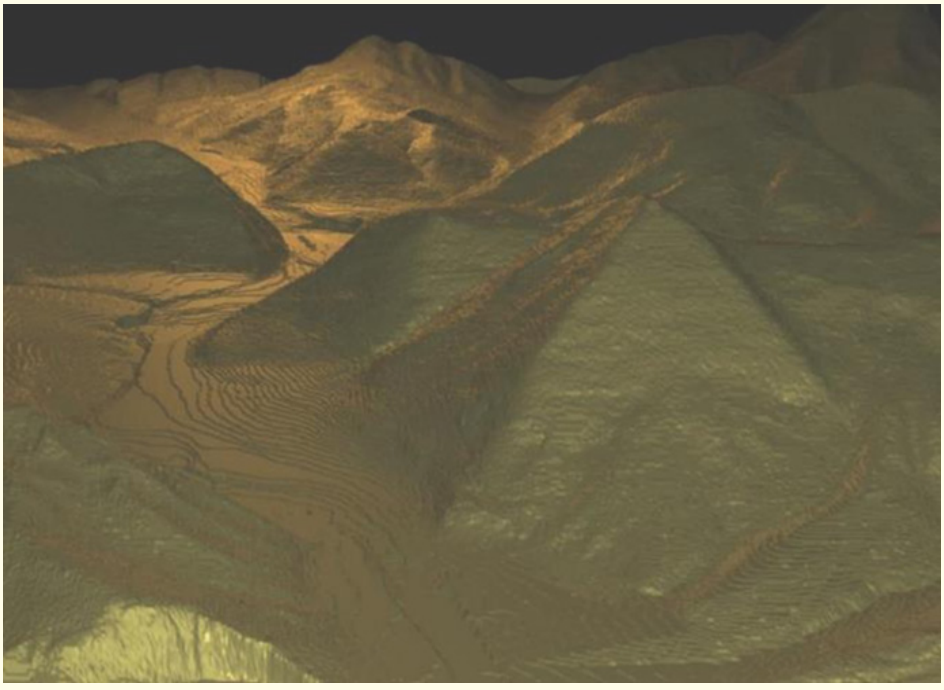

Figure 8: 4D visualization of the Bosnian Pyramid of the Sun.

Methodology: polygonal terrain modeling using satellite images, photogrammetry, and 3D software. Visualization: M.Sc.Eng. Senad Bahor. New Methodology for the reconstruction of the Cultural Heritage Site.

Source: Osmanagich, S. My Story (2023): 108-109. [7].

Nubian pyramids: Cardinal alignments in the kingdom of Kush

In the region of ancient Nubia, present-day Sudan, over 200 pyramids were constructed by the rulers of the Kingdom of Kush, particularly during the Napatan and Meroitic periods (circa 700 BCE–350 CE). These pyramidal structures, primarily located at Meroë, Nuri, and El-Kurru, differ architecturally from their Egyptian counterparts in steepness and scale but share a notable geospatial feature: deliberate cardinal orientation [8,9].

While detailed measurements of individual alignments are still limited in academic literature, available archaeological assessments indicate that many of the Nubian pyramids were intentionally aligned with the cardinal compass points. In particular, the eastern-facing chapels of these pyramids were oriented to receive the rising sun, a design that reinforced ritual practices involving illumination and solar symbolism. This architectural principle, found consistently across numerous pyramid fields in Sudan, suggests that the builders applied a conscious geodetic or astronomical method when establishing site orientation.

While the specific methods used by the Kushite builders remain uncertain-whether through solar observation, stellar tracking, or

horizon-based techniques-the orientation of the Nubian pyramids fits within a broader pattern of cardinally aligned sacred structures across civilizations.

Monks mound and cardinal planning in ancient north america

Across the Mississippi River from present-day St. Louis, the Cahokia Mounds State Historic Site contains the remains of the most sophisticated pre-Columbian city north of Mexico. Its central feature, Monks Mound, is the largest ancient earthen structure in the Americas-rising approximately 30 meters and covering 5.6 hectares. Archaeological evidence indicates that the builders of Cahokia, belonging to the Mississippian culture (circa 1050–1350 CE), demonstrated a deliberate understanding of spatial organization and cosmic alignment [10].

The entire site, including Monks Mound and its associated plazas and causeways, was planned along cardinal axes. Four main plazas extend in cardinal directions from Monks Mound's summit, and the Rattlesnake Causeway, which connects Monks Mound to the southern mound precinct, is aligned 5° east of true north-a deviation that may intentionally mirror certain lunar standstill positions.

Additionally, nearby Woodhenge structures, formed by concentric timber circles, functioned as solar observatories. From the central viewing post, observers could mark solstices and equinoxes based on the sunrise's position relative to fixed posts on the horizon. These features demonstrate that cardinal and solar alignments were central to the cultural and ceremonial planning of the site.

While the Monks Mound itself does not match the precision of structures like the Bosnian or Egyptian pyramids, its large-scale orientation reflects a conscious engagement with the cardinal and celestial order, making Cahokia a valuable point of comparison in global pyramid alignment studies.

Selected Latin American pyramids: Cardinal and astronomical orientations

Across Mesoamerica and Central America, ancient civilizations constructed pyramids and temple complexes with remarkable architectural sophistication and celestial awareness. However, unlike the consistent cardinal orientation seen in Egypt, China, and Bosnia, Latin American pyramid alignments display more variation-often reflecting solar, calendrical, or ritual functions rather than strict geodetic alignment.

Still, several key examples exhibit clear and deliberate cardinal orientation, making them suitable for inclusion in comparative analysis:

- **El Castillo (Temple of Kukulcan), Chichen Itza, Mexico**: The structure is aligned with solar events-most famously during equinoxes when the setting sun creates the illusion of a serpent descending the pyramid's staircase.
- **El Castillo at Xunantunich, Belize**: This Maya site features a central pyramid aligned to the cardinal directions. It is described as the "axis mundi" of the site, signifying its cosmological centrality.
- **Pyramid of the Niches, El Tajín, Mexico**: This unique seven-tiered pyramid is also oriented to the cardinal points and features 365 niches, interpreted as a symbolic representation of the solar year. The architectural layout integrates both calendrical and directional symbolism.
- **Temple I (Temple of the Great Jaguar), Tikal, Guatemala**: This structure is oriented east-west, with its stairway facing the rising sun. The alignment reflects the Maya tradition of aligning ceremonial structures with solar movements, particularly solstice and equinox points [11].

These examples show that while not all Latin American pyramids were oriented to true north, some sites exhibit precise cardinal alignment, aligning them with global patterns of geospatial intentionality.

Transition: Toward a global pattern

The survey of pyramid structures across five continents reveals a consistent pattern: many ancient civilizations oriented their monumental architecture with deliberate reference to the cardinal directions, particularly true north. While methods and cultural contexts varied, the precision observed in sites such as Bosnia, Egypt, and China, and to a lesser degree in Sudan, North America, and Latin America, suggests that orientation was not incidental, but foundational to architectural planning. The following section synthesizes these findings to examine what they reveal about ancient geodetic knowledge and the symbolic or cosmological meaning attributed to true north.

Comparative analysis and interpretation

The Bosnian Pyramid of the Sun, with its confirmed orientation of 0° 0′ 12″, demonstrates the highest degree of cardinal precision among all measured pyramids in this study. This level of alignment, verified by both LIDAR and geodetic surveys, surpasses even the Great Pyramid of Egypt, which deviates by approximately

3 arcminutes (0° 0′ 3″). Chinese pyramid-like structures, such as the Yangling Mausoleum, also show minimal deviation (~27 arcminutes), supporting the idea of intentional geospatial alignment based on astronomical or terrestrial reference systems.

The Egyptian pyramids at Giza and Dahshur display consistency in cardinal orientation across multiple sites, likely achieved using stellar observation techniques. Similarly, the Nubian pyramids show a strong tendency toward cardinal alignment, particularly in the east-west axis of ritual chapels. Though specific angular data is limited, archaeological accounts confirm the intentionality behind their orientation.

In the Americas, the orientation pattern is more diverse. Monks Mound at Cahokia was embedded in a cardinally structured urban layout, while associated solar observatories like Woodhenge demonstrate precision in solstice and equinox tracking. Latin American pyramids such as Temple I at Tikal show that cardinal orientation was present in certain cases, but often interwoven with solar and calendrical considerations, leading to broader variation in angular precision.

What unites these globally dispersed sites is a shared architectural emphasis on cosmic or geospatial order. Whether through direct observation of celestial bodies, shadow tracking, land surveying, or other techniques, the builders of these ancient structures encoded directionality into stone, earth, and space. The alignment to true north, in particular, emerges not as a regional anomaly, but as a recurring global principle-indicating a high level of astronomical awareness, symbolic intent, and perhaps even shared conceptual frameworks in ancient knowledge systems.

Methodologies and Limitations

The comparative approach in this study relies on a combination of empirical field measurements, remote sensing technologies, and archaeological documentation from diverse global contexts. For modern structures such as the Bosnian Pyramid of the Sun, orientation data has been established using high-precision Total Station instruments (Buza, 2007) [5] and LIDAR scanning (Airborne Technologies GmbH, 2015–2022) [6]. These tools provide reliable and replicable geospatial data with sub-meter accuracy, forming a strong basis for orientation analysis.

For Egyptian pyramids, orientation data is well-documented in the literature. Researchers such as J.A. Belmonte (2001) [2], Kate Spence (2000) [12] and Glen Dash (2017) [3] have conducted both re-measurements and analytical reviews of pyramid orientations, noting consistently small deviations from true north across the Giza and Dahshur complexes. Their methodologies typically involved stellar observation reconstructions, especially using circumpolar stars or the simultaneous transit method.

The Yangling Mausoleum orientation was obtained through direct field measurements presented by Chinese archaeologists Dr. Jiao Nanfeng and Dr. Cao Fazam at the 2008 International Scientific Conference on the Bosnian Pyramids. Their use of geodetic equipment aligns with current standards for high-resolution orientation analysis.

In the case of the Nubian pyramids, while explicit angular data is limited, archaeological consensus supports a pattern of east-facing chapels and cardinal alignment based on consistent architectural design across multiple pyramid fields (African History Extra, 2021; Daily JSTOR, 2018). Further survey data is needed to quantify these patterns more precisely.

For North and Latin American structures, orientation data is drawn from archaeoastronomical studies (e.g., Milbrath and Dowd, 2017; Aveni, 2001) [10,11], field surveys, and site documentation. While Monks Mound and El Castillo clearly demonstrate cardinal or astronomical alignment, the methodologies used by original builders-such as horizon tracking, shadow casting, or solar markers-remain speculative in some cases.

Limitations

This study acknowledges several limitations:

- **Variability of data precision**: Not all measurements come from uniform methods or instruments; historical sources often use estimates or generalized orientations.
- **Cultural differences in intent**: Alignment may have served different symbolic or functional roles across civilizations. For example, while cardinal alignment in Egypt may relate to cosmic order, Mesoamerican pyramids often reflect solar calendrical functions.

- **Preservation and topographical changes**: Erosion, reconstruction, or shifting terrain may affect current readings of ancient orientations.
- **Selection bias**: This study focuses on better-preserved or better-documented pyramids; many lesser-known or inaccessible sites could offer additional insights.

Despite these challenges, the compiled data presents a compelling pattern: a broad application of true north alignment across space and time, achieved by cultures with no direct contact. This observation warrants deeper interdisciplinary investigation combining archaeology, geodesy, astronomy, and comparative architecture.

Conclusion

The global survey of pyramid orientations presented in this study reveals a compelling pattern: diverse ancient cultures, across five continents, repeatedly aligned their monumental structures toward true north or other cardinal directions. This pattern is observed with exceptional precision in the Bosnian Pyramid of the Sun (0° 0′ 12″), the Great Pyramid of Egypt (0° 0′ 3″), and the Yangling Mausoleum in China (359° 32′ 25.6″). Pyramids in Nubia, North America, and Latin America also show evidence of cardinal or astronomical alignment, though with more variation in angular precision and symbolic context.

The recurrence of cardinal alignment-particularly to true north-suggests more than coincidence. It points to a global architectural principle, possibly rooted in shared cosmological paradigms or a universal recognition of the Earth's geospatial orientation as a sacred or organizing force. This study does not claim direct cultural transmission between civilizations but emphasizes the parallel development of geodetic and astronomical knowledge in ancient architectural planning.

The inclusion of precise measurement data, historical surveys, and recent geospatial technologies reinforces the idea that these structures were not arbitrarily placed. Instead, their orientation was the result of deliberate design, reflecting a high level of technical understanding and a desire to embed cosmic order into built form.

Future interdisciplinary research, especially with expanded LIDAR surveys, archaeoastronomical modeling, and site-specific orientation studies, may further illuminate the cognitive and symbolic frameworks that guided the global phenomenon of pyramid alignment.

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Author Contribution

Dr. Sam Osmanagich: Conceptualization, data compilation, Bosnian site coordination, manuscript writing

Conflict of Interest Statement

The author declares no conflicts of interest related to the research, analysis, or publication of this article.

Ethical Approval

This research did not involve human or animal subjects. All measurements, site visits, and remote sensing activities were conducted under appropriate institutional and local permissions, including support from the Archaeological Park: Bosnian Pyramid of the Sun Foundation and municipal authorities in Visoko, Bosnia-Herzegovina.

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