



## **DESCRIPTIVE GEOMETRY: CENTRAL AND PARALLEL PROJECTIONS AND THEIR GEOMETRIC AND MATHEMATICAL PROPERTIES**

Yuldashev Solmonjon Iqboljon ugli

Intern-Teacher at the Department of Architecture and Hydraulic Engineering Andijan Institute of Engineering

### **Abstract**

This article provides a comprehensive scientific analysis of the geometric and mathematical foundations and characteristics of central and parallel projections used in descriptive geometry. The scientific significance of projections in the accurate and realistic representation of spatial objects, their wide application in technical fields, and their comparative features are thoroughly explored. The historical development of descriptive geometry, the basic principles of projection theory, and their practical application are also examined in detail.

**Keywords:** Descriptive geometry, central projection, parallel projection, perspective distortion, spatial perception, Monge method.

### **Introduction**

Descriptive geometry is an essential engineering discipline that enables the depiction of spatial shapes and volumes of objects using graphical methods. Its development began in ancient civilizations such as Egypt, Greece, and Rome, where the first graphical illustrations emerged from the needs of construction and architecture. The precise geometric depictions in the construction of Egyptian pyramids and Greek temples serve as early examples in the history of this science. Later, during the Roman period, perspective drawings began to evolve, laying the foundation for graphical representations of spatial shapes.

In the Middle Ages, especially in Eastern countries, mathematics and geometry advanced significantly. The scientific works of great scholars such as Al-Khwarizmi, Al-Farghani, Al-Biruni, and Ibn al-Haytham played a major role in elevating descriptive geometry to the next level. Ibn al-Haytham's studies in optics were among the first to scientifically substantiate the foundations of perspective



drawing. During the Renaissance, European artists and engineers such as Leon Battista Alberti, Leonardo da Vinci, and Albrecht Dürer further developed the scientific aspects of descriptive geometry. Leonardo da Vinci's techniques for spatial representation were especially important for the development of realistic projection.

In the late 18th century, the French mathematician Gaspard Monge established the scientific basis of descriptive geometry. His theory laid the groundwork for representing objects graphically using planes and spatial coordinate systems. Monge's work defined the scientific principles of depicting objects through parallel and central projections. His contributions led to the development of the widely used "Monge projection" method, which allows for clear and accurate representation of spatial positions.

In modern times, the development of technology and informatics has brought descriptive geometry into a new era. Computer graphics, computer-aided design (CAD) systems, and virtual modeling technologies are all based on the principles of descriptive geometry. In engineering—particularly in mechanical engineering, construction, architecture, and aviation—the accurate depiction and modeling of objects rely heavily on central and parallel projections.

Central projection plays a crucial role in creating representations that resemble actual visual perception. This type of projection is widely used in art, design, animation, and architectural visualization. In contrast, parallel projection is commonly used in engineering and technical design, where preserving the original dimensions of geometric shapes is essential. Therefore, a thorough and complex study of both types of projections and their geometric and mathematical foundations is an important scientific task. The main goal of this research is to scientifically justify and analyze the two types of projections in descriptive geometry—central and parallel—from historical, theoretical, and practical perspectives, determine their distinguishing features, and assess the possibilities for their application. As a result, new opportunities will be created for graphical representation methods, and scientific-practical recommendations will be developed to further improve the teaching of descriptive geometry.



## **Methodology and Literature Review**

In this research, a combination of theoretical-analytical, structural-systematic, comparative, and empirical methods was used to comprehensively study the scientific foundations of central and parallel projections.

The theoretical-analytical approach was applied to thoroughly examine the classical theories and methodological foundations of descriptive geometry developed by Gaspard Monge. Key concepts and methods such as spatial coordinates, projection planes, and visualization techniques described in Monge's theory were analyzed in depth. To further elaborate on these methodological foundations, the scientific and theoretical materials of N.G. Monakhov's *Descriptive Geometry* (2010) and *Chizma Geometriya* (2008) by Sh. Murodov et al. were extensively used. These sources provided insight into the mathematical formulas and geometric rules used for graphical representation, as well as their applicability in modern technologies.

The structural-systematic approach was employed to study the systemic relationships in the graphical representation of objects, their geometric and mathematical characteristics, and structural aspects. This method allowed for a deeper analysis of how projection theory contributes to the identification and representation of spatial characteristics of objects. The mathematical foundations of central and parallel projection systems, their geometric constructions, and the primary methods used in their construction were examined in detail. This section also discusses theoretical models, geometric rules, and mathematical expressions used in graphical representation, along with their practical implications. The internal structures of these theories were revealed by identifying the components of projection systems and their interrelations.

Through comparative and empirical methods, the practical and theoretical possibilities for using projections and their advantages in technical fields were identified. The comparative analysis elaborated on the different characteristics of central and parallel projections, particularly their differences in representing objects realistically versus technically. The geometric precision of parallel projections and the illustrative potential of central projections were contrasted to determine their suitability for various purposes in graphical representation.

Empirical research focused on evaluating the effectiveness of these projections in actual visualization processes. The accuracy and quality of object representations



using each projection method were critically analyzed. Furthermore, the roles and significance of modern computer graphics and CAD tools in graphical representation were thoroughly explored. These studies revealed the potential for integrating descriptive geometry and projection theory with modern technologies.

## **Results and Discussion**

Central projection is a method that reflects the actual visual characteristics of how the human eye perceives objects. Its mathematical model is expressed as:

$$X' = X(d/Z), Y' = Y(d/Z)$$

This formula represents the process of projecting a spatial object onto a plane. One of the main features of central projection is **perspective distortion**, which depends on the distance between the object and the projection center. As the object approaches the center, its image becomes larger; as it moves away, the image becomes smaller. In central projection, parallel lines converge at a vanishing point, enabling a realistic representation of spatial positions. This property is widely used in architecture, design, and the arts.

Parallel projection, on the other hand, involves projecting rays that are parallel to one another. Its mathematical expression is:

$$X' = X, Y' = Y$$

In this case, the original dimensions of the object are preserved, meaning there is no geometric distortion. This feature is essential in technical and engineering design. In technical drawings and production processes, parallel projection is used to accurately depict object dimensions. It provides a reliable means for conveying precise specifications.

A comparative analysis of central and parallel projections shows that both methods have distinct advantages and should be chosen based on the intended purpose of the visual representation. Central projection is ideal for realistic and illustrative applications, while parallel projection is better suited for technical tasks requiring exact measurements.

## **Conclusion and Recommendations**

Based on the findings of this research, the significance of central and parallel projections in descriptive geometry has been further clarified. The study shows that both types of projections have unique geometric and mathematical characteristics



and are widely used in technical fields. The advantage of central projection lies in its alignment with the laws of geometric perspective, enabling realistic depiction of objects, while parallel projection is crucial for maintaining object dimensions and ensuring technical accuracy.

Additionally, as revealed in the research, the use of both projection types in graphical representation requires specific theoretical knowledge and practical skills. Therefore, it is necessary to deepen students' understanding of central and parallel projections within the framework of descriptive geometry. Higher education institutions—especially in engineering and architecture—should develop and implement specialized educational programs dedicated to these projection methods.

Furthermore, to enhance students' spatial perception skills, new teaching methodologies should be developed that utilize modern technologies such as computer graphics and CAD systems. Empirical studies confirm that these technologies allow for realistic and geometrically accurate representation of objects. The research also highlighted the need to develop new methodological approaches and software tools to optimize object visualization processes in technical and engineering design.

Future scientific research and practical developments should focus on creating new visualization methods, improving the teaching of descriptive geometry, and enhancing the effective use of projection theory in engineering practice. The preparation of scientific-methodical manuals and the improvement of professional training systems are identified as important scientific and practical objectives.

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