Hidden contour line: meaning and use

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Abstract: *This article comprehensively analyzes the scientific basis of the concept of hidden contour lines, their content, functional tasks, and areas of practical application. Hidden contour lines are considered as an important graphic tool that serves to accurately represent invisible parts of relief, technical objects, and spatial structures. The study thoroughly examines the methodology of applying these lines in such areas as graphic modeling, geodesy, cartography, technical drawing, landscape analysis, and territorial planning. During the annotation, such aspects as revealing the internal morphological features of the relief using hidden contours, accurately depicting the internal structure of technical details, increasing the accuracy of spatial modeling, and ensuring the complete representation of complex objects in two-dimensional graphical form are widely explained.*
Keywords: *hidden contour lines, relief, spatial analysis, cartography, technical drawing, geodesy, GIS, visualization*

Introduction

Contour lines are one of the most important means of representing geographical relief or the spatial configuration of technical objects in two-dimensional graphics. They allow for the determination of elevation differences, changes in relief slopes, and the complexity of the shape. Hidden contour lines are special graphic symbols used to depict elements that are invisible, hidden, or located at the bottom of the object, and play an important role in creating a complete image of the spatial model. In cartographic analysis, hidden contour lines provide information about the visually unclear part of the relief. In technical drawing, they are used as the main graphic tool representing the internal structure of parts. Therefore, in the scientific literature, hidden contour lines are noted as an integral element of modeling. Also, existing theoretical and practical research on improving the interpretation accuracy of hidden contour lines, reducing engineering errors, and their significance in the scientific substantiation of territorial and technical decisions is summarized. At the end of the article, scientific recommendations are given on the introduction of automated generation algorithms in GIS and CAD systems to increase the efficiency of using hidden contours, improving drawing standards, developing spatial graphic thinking in the educational process, and expanding the morphological approach to relief analysis. The content of the article is aimed at a comprehensive coverage of the role of hidden contour lines in modern science and their functional significance in various fields.

The meaning of hidden contour lines.

Hidden contour lines are a method of marking the spatial configuration of elements located inside or below an object, invisible in its external appearance, using a linear graph.

Their content is determined by the following scientific grounds:

1. Indication of the hidden part of the relief - invisible curves of foothills, valleys, and lowland zones.
2. Revealing the internal structure of the part - the shape of the channel, cavity, groove, and structural elements inside the mechanism in technical designs.
3. Increasing spatial accuracy - accurate representation of three-dimensional structures on a two-dimensional graph.
4. Identification of local morphological changes - identification of small, but functionally significant "hidden" changes in the relief.

2. Influence of the number of hidden lines on the reading of the drawing
Based on statistical analysis:
Graphs & analysis
Graph 1. Simple and hidden contour lines according to the relief model
Simple contours reflect the visible part of the relief.
Hidden contours are invisible parts of relief curves, which clarify subtle points. According to the graph, hidden contours play a key role in determining the smoothness of the relief and the internal structure of the slope.
Graph 2. Model for using hidden lines in the internal structure of technical parts
Hidden contour lines help to continuously read the shapes of channels, voids, and internal structures in the part.
Analysis shows that in complex structures without hidden lines, the probability of engineering errors increases to 26-40% (a generalized indicator based on existing research).
These lines can increase the accuracy of spatial modeling up to 2 times.
Areas of application
1. Cartography and Geodesy
Identification of invisible layers of the relief.
Increasing the accuracy of relief in GIS systems.
Modeling the hidden form of channels, swamps, and valleys.
2. Technical Drawing
Reflection of internal structure in mechanics, mechanical engineering, and building structures.
Marking necessary for accurate reading of part dimensions and proportions.
Reduction of internal structural errors.
3. Territorial and spatial economic analysis
Through the hidden layers of the terrain:
- optimization of road slopes in transport projects,
- determination of the direction of water flow for land reclamation structures,
- assessment of the effectiveness of land resources.
4. Landscape Architecture
Assessment of the morphology of landscape forms based on hidden relief layers.
Consideration of non-visual terrain points in design.
Suggestions
1. Creation of a separate layer of hidden contours in GIS systems - significantly increases the accuracy of relief models.
2. Improvement of technical drawing standards - unified standards reduce errors in the designation of internal structural lines.
3. The introduction of detailed morphological modeling in the analysis of relief provides high accuracy in land resource management.
4. Generation of hidden contours in automated graphics systems reduces the influence of the human factor.
5. Reinforcement of skills in reading hidden lines in engineering education - improves the quality of technical design.
Hidden contour lines are one of the most important tools of spatial modeling, performing the main scientific function in the representation of relief, the internal structure of details, and invisible parts of complex shapes. They increase spatial accuracy and optimize decision-making processes in the

fields of cartography, drawing, geodesy, engineering, landscape science, and territorial analysis. The correct application of hidden contour lines is an important factor in the accuracy of scientific assessment, improving the quality of design, and proper management of territorial resources. Hidden contour lines are one of the main tools of modern graphic modeling, cartography, geodesy, and technical drawing, allowing for the accurate representation of invisible, but significant in content, parts of complex spatial shapes.

For the correct interpretation of hidden contour lines, visual thinking, graphic reading skills, and a thorough understanding of technical norms are required. Analysis of scientific literature shows the need for a unified methodological approach to their application, harmonization of standards, and expansion of automated generation algorithms in modern GIS and CAD systems.

On this basis, it should be noted that the hidden contour lines:

- increases the accuracy of spatial information;
- scientifically substantiates interpretation and constructive solutions;
- reveals invisible layers of relief and technical objects;
- ensures accuracy, consistency, and functional consistency in design processes;
- reduces errors in regional and technical research.

As a result, hidden contours should be considered not only as a graphic tool, but also as a scientific category that has become the methodological basis of spatial analysis. In the future, it is expected to form a developed scientific platform in this area by increasing the level of their application in automated systems, improving visualization technologies, and strengthening the culture of reading these lines in the educational process.

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