

# Principles of Three-Dimensional Computer Design for Understanding Impossible Figures

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*Abstract: For a better understanding of the impossible figures, it is advisable to use modern technological means by which the design of the geometry of the models gives a complete understanding of how they are made. Computer-aided 3D design completely solves this problem. That is, on the one hand, the ultimate visual variant of impossible figures is created, on the other hand, there is the possibility for real manipulation, movement, rotation and other models of space. In this study, 3D models of impossible figures are fully constructed, which are applied in the educational process in order to develop logical thinking. The steps of creating 3D geometry using open source software Blender 3D are described in details.*

*Keywords: 3D, Blender, logic, impossible, figures*

## Introduction

Impossible figures are combinations of geometric elements positioned in specific compilations that create the illusion of completed objects, but at the same time have an extremely impossible vision. This is especially the case when certain details are interwoven in a particular order or position. Creating them requires a rich imagination and understanding of three-dimensional space. Impossible figures are a good tool for developing logical thinking, creating creativity in adolescents, and are often used in the educational process. Impossible figures are present in the visual arts, architecture and spatial form shaping. These types of figures are challenging for both the users and the authors of the compositions themselves. In the development of conceptual designs, various techniques are used, based on the knowledge related to conventional geometry, spatial vision and exact isometric coordinates. Some of the popular models of impossible figures were created as sculptures by Australian artist Brian Mackay and architect Ahmad Abbas [1 - 3].



Figure 1. Popular sculptures of impossible figures [1-3]

The impossible figures are the inspiration of the Dutch graphic artist M.C. Escher, who has sketched the popular artworks "Waterfall", "Belvedere", "Ascending and descending", and more [4-9].

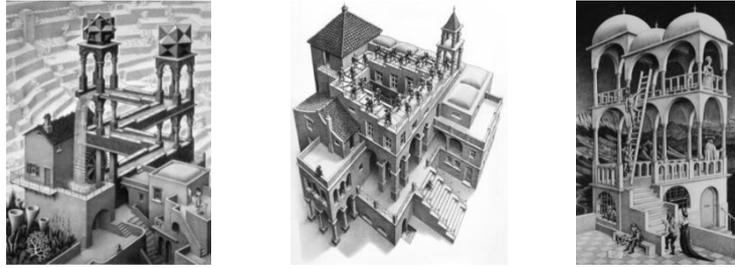


Figure 2. Popular works by the Dutch graphic artist M.C. Escher. From left to right: "Waterfall", "Belvedere", "Ascending and descending" [4-9]

Over time, impossible figures have become increasingly popular and interesting to a wide range of professionals, ordinary people, adolescents, and people with multiple interests. Impossible figures begin to be interpreted in architecture, in interior and exterior design, in computer and mathematical modeling. In certain cases elements are borrowed or involved in diverse compositions [10–19]. This is possible when conventional design, modeling and other design techniques are applied [20–25]. Based on these, hybrid models have been successfully implemented. In recent years, there has been a steady increase in video and animation and other types of interpretations of impossible figures in combination with physical processes, where the emphasis is on the influential effect of perceptions in order to develop logical thinking and improve spatial-analytical memory [26–30].

## Materials and methods

Creating three-dimensional geometry of impossible figures is a challenge not only logically but also technically and constructively. It is necessary to make the right selection of applicable software, knowing the technical capabilities of the program, in accordance with the approach applied by three-dimensional designers. A good solution is the 3D Blender program [31–37]. It has all the resources available to fulfill the set goals, and through it it solves the tasks related to the development of three-dimensional geometry. The following are relevant:

- The individual logical approach of the designer;
- Conventional Blender 3D Design Technique;
- Application of specialized modifiers in the work process.

Figure 3 shows the digitally realized 3D models of impossible Penrose Triangle, Penrose Stairs, and Necker Cube figures;

In this study, the technique for visualizing a selected developed model (Penrose Triangle) is presented in a sequence that fully reveals the way in which it is possible to design an impossible model that actually has real correct geometric characteristics.

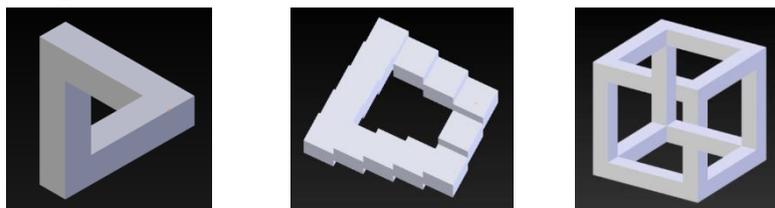


Figure 3 Computer made 3D models of impossible figures using open source Blender software 3D. From left to right: Penrose Triangle; Penrose Stairs; Necker Cube.

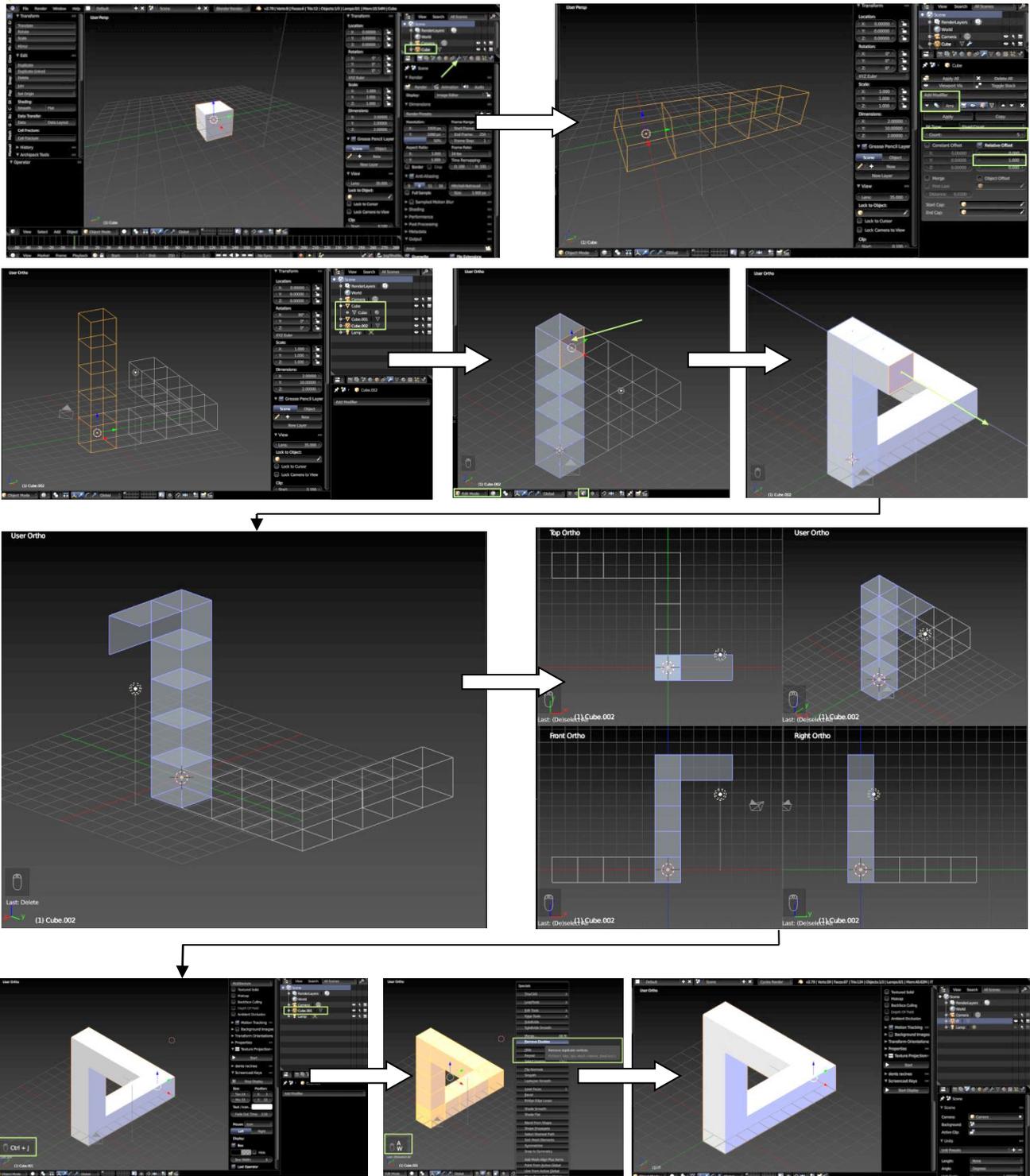


Figure 4 Computer made 3D model of an impossible Penrose Triangle figure through open source Blender 3D software. In sequence: From left to right: Propagation of the original primitive 3D cube x 5, using modifier Array. Duplicate Object twice, the second rotates on the x: 90 ° vertical. In Edit Mode, the top inner face is extruded to the appropriate position. The same profile takes away some parts of the faces as shown in the figure. The three-dimensional geometry is combined into one object, with Remove Doubles triggered in the final phase ("W" key B Edit Mode). The 3D triangle object is positioned in the appropriate camera position and the final image is finalized - impossible figure.

Using a similar technique when working with Blender 3D software, three-dimensional Penrose Stairs and Necker Cube models are made (Fig. 5 and Fig. 6). The 3D Penrose Stairs model is constructed by sequentially duplicating the original cubic primitive on levels, modifying three steps in the third-highest rotation (first and second are with 5 steps each). By focusing at a certain angle, the illusion of impossibility of geometry is created. The two images in FIG. 5 shows the design of the construction in detail from different sides. The Necker cub is made by modeling vertical and horizontal profiles, interrupting two of them in Edit Mode on Blender 3D software. At a certain angle, the view is focused, creating the illusion of wholeness and at the same time impossibility. FIG. 6 shows the construction from different angles.

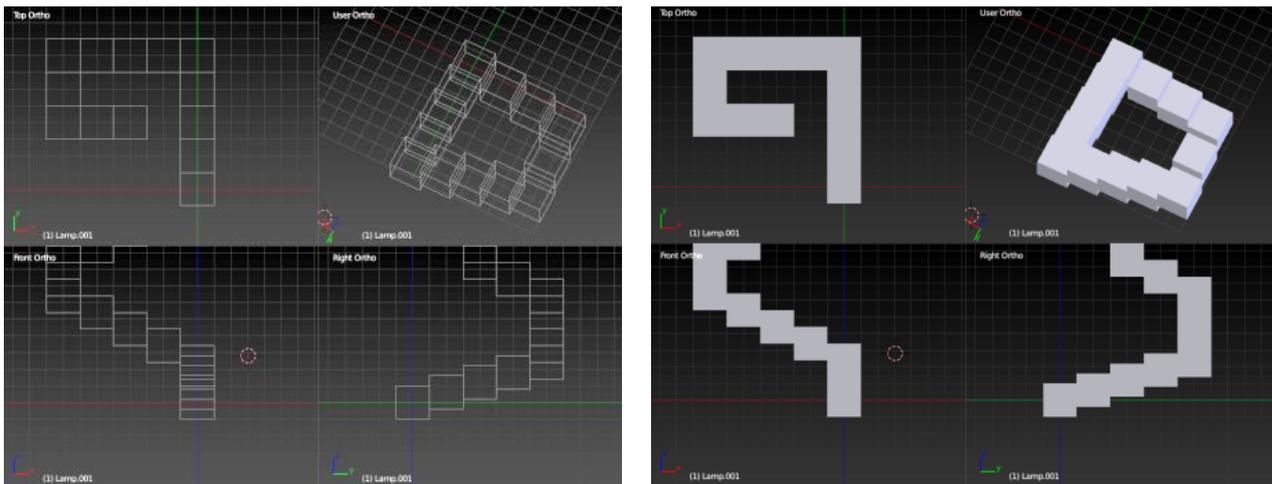


Figure 5 A computer made 3D model of an impossible figure using open source Blender 3D software: The Penrose Stairs.

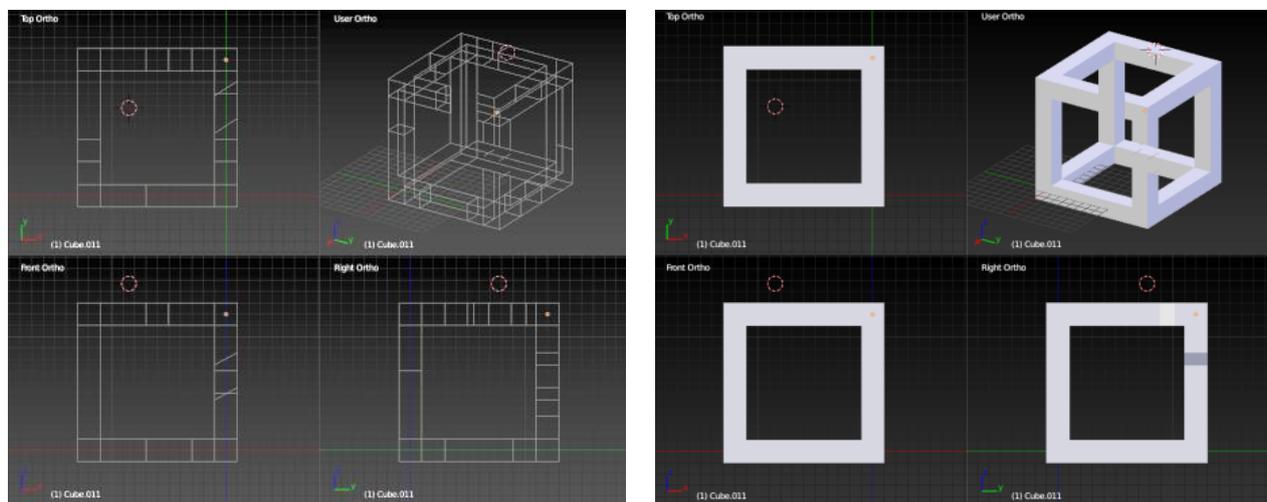


Figure 6 Computer made 3D model of impossible figure using open source software Blender 3D: The Necker cub.

## Conclusion

In this study, three-dimensional models of popular impossible figures have been digitally developed. The obtained results are distinguished by their precise and properly built construction, with the necessary conditions being met. The stages of construction are presented in details, as well as the

basic views, which illustrate the geometric features of the models, are applied. The resulting ready-made models are presented in a way that is accessible to a wide range of users who may have access to data as intended. And namely: getting acquainted with popular examples; application of three-dimensional models in the educational process; exploring the possibilities of logical thinking; building creative qualities; developing technical skills for working with the open source 3D Blender system.

## Acknowledgments

The described work was carried out as part of the research “Advanced technologies in design”

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