

Computer parametric designing in Blender software for creating 3D paper models

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Abstract. *In the contemporary conditions, the implementation of computer parametric design to facilitate the design of 3D paper models is successfully realized using modern technological tools such as the free software Blender. Through the convenient interface of the program, the modeling of the desired three-dimensional shapes is greatly facilitated. This also applies to the automated process of constructing a drawing of the resulting polygonal 3D models, which in the future are assembled into three-dimensional paper models. This paper describes in detail the process of fine-designing 3D paper models using specific exemplary primitive, text, and with relatively complex form.*

Keywords: 3D, Blender, parametric, paper, models

1 Introduction

3D paper models find a versatile application in practice. Their scope covers various areas such as art-design (Molina i-link, 2017), sculpture (Straub & Hartmut, 2011), advertisements, decorations, jewelry (Karen i-link, 2017), models of architectural elements, modern and historical buildings and facilities (Xian-Ying, Chao-Hui, Shi-Sheng, Tao & Shi-Min, 2010). They are used to recreate completely urbanized and geographic areas (Tau & Lahr, 1991; Tau & Laslie, 1990), important for the packaging industry (Roth & Wybenga, 2012) etc. Depending on the specific activity, the design and construction of 3D paper models is done by manual work, which requires certain technical skills (Birmingham, 2006; Conrado, Sang & Yum 2014; Райчев, 2002) or it can be automated by using different technical means. A very good modern technological tool is the Blender software (Dovramadjiev, 2015). It is fully accessible with its free and open source license (Alecú, 2010). The Blender program is distributed based on GNU General Public License (Blender - GNU i-link, 2017; GPL i-link, 2017).

The Blender program is an environment for developing 3D polygonal mesh models (Blain, 2012; Chopine, 2011; Chronister, 2009 & 2011; Wickes, 2009; Пpaxов, 2009). This is the basis on which additional capabilities have been built with different strands - both pledged and externally available - add-ons. In the process of releasing new software versions, additional capabilities are enriched with new and / or sophisticated features. The capabilities of additional add-ons applications are growing in variety. Important clarification about external add-ons is their direct purpose for the particular version of Blender. Some of them are sustainable in time and are active in both the older and the newer ones. Similarly, the integration of the specialized application (Export: Paper Model (.svg)) to make 2D print sheets from 3D mesh models in Blender's environment originally appeared as an external add-on by author Addam Dominec. The application is completely free of charge on the Internet: https://wiki.blender.org/index.php/Extensions:2.6/Py/Scripts/Import-Export/Paper_Model. Downloading the application (file name: `io_export_paper_model.py`) and its subsequent integration for the newer versions of Blender is not necessary due to the fact that the application is already embedded in the basic package of the most current version of Blender 2.79 (December 2017;

<https://www.blender.org/download/>). Activating the application Export: Paper Model application in Blender software is shown in figure 1.

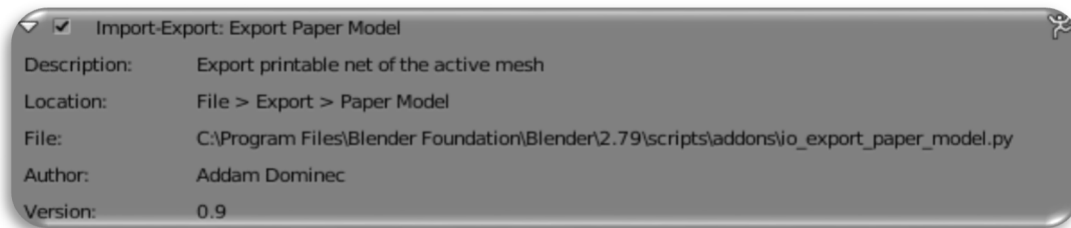


Fig. 1. Activating the application Export: Paper Model add-on.

2 Materials and Methods

In the present study, using the Blender program and parameterization, the following three-dimensional mesh models will be developed:

- 2.1 Three-dimensional primitive - cub;
- 2.2 Three-dimensional letters – Text;
- 2.3 Three-dimensional models with relatively complex shape - diamond (2.3.1) and gem (2.3.2).

After receiving the desired three-dimensional shape of the models, they will be automatically unfolded on a 2D drawing. The received files have a * .pdf extension. They contain high-quality drawing features including dull lines (for cropping), dashed lines (for folding), glueing areas, inscriptions, “islands”, and reinforcing bonding gaps (integrating larger volumes).

The exact sizing of the patterns is set in the Scene panel by selecting the unit of measure. By default, Blender works with a unit of measure - meter. It is also good to consider the printing device and the shape of the sheet.

2.1 Development of 3D primitive – cub

The Blender program is set so that after the work area is insulated and released, a three-dimensional cube model (Fig. 2a) is positioned with the parameters shown in Table 1.

Table 1. Parameters of 3D model–cube.

Coordinates	Scale	Dimension /m
X	1	2
Y	1	2
Z	1	2

Using the application Export: Paper Model, the cube model is exported to a * .pdf file format. This is done by using File-> Export → Paper Model (svg) and specifying a folder where the file name is entered. Figure 2b shows the model's completed loop.

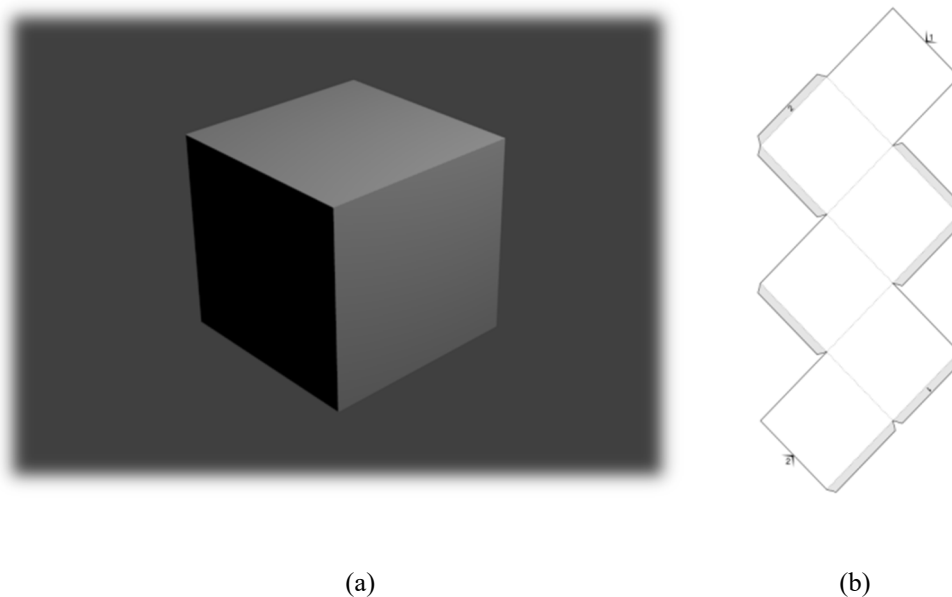


Fig. 2. Activating the application Export: Paper Model add-on (a) 3D model cube, (b) unfold.

2.2. Developing three-dimensional letters –Text

Three-dimensional text in Blender is obtained using Add → Text and manually displays the desired word, a single letter or a character in Edit Mode. Object Data defines extruding values. In this case: Modification \ Extrude: 0.1 (Fig. 3).



Fig. 3. Three-dimensional model – „Text”.

In order to create the paper unfolding, it is desirable that the letters have to be generated individually, thereby undergoing a process of reconstruction of the polygonal mesh. For the selected Object letter, select Convert to and Mesh from Curve / Meta / Surf / Text (Alt C). The result shows that the resulting polygon mesh of the letter is poorly ordered. Therefore, in the modifier section, Remesh is selected and in the Object Mode mode the polygonal mesh is reconstructed. In order to obtain a precise and well-built mesh, it is necessary to select all elements of the 3D model in Edit mode before using the Remove Doubles. Fig. 4 shows the initially constructed letter T (4a), Remesh (4b) and the resulting unfolding (4c).

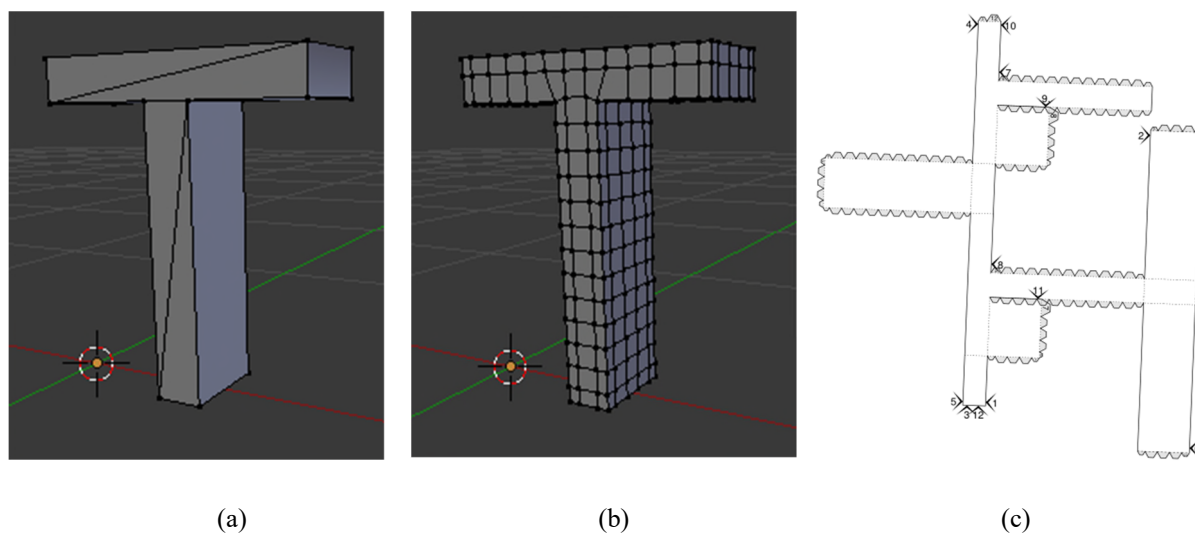


Fig. 4. Three-dimensional model - letter "T" - part of "Text" (a) polygonal mesh resulting from conversion, (b) reconstructed polygonal mesh, (c) unfold.

The unfolding of the other letters of "Text", respectively "e", "x" and "t" are shown in fig.5. It is important to specify that the images have to be proportionate when printing - in this case they are arranged disproportionately in a row.

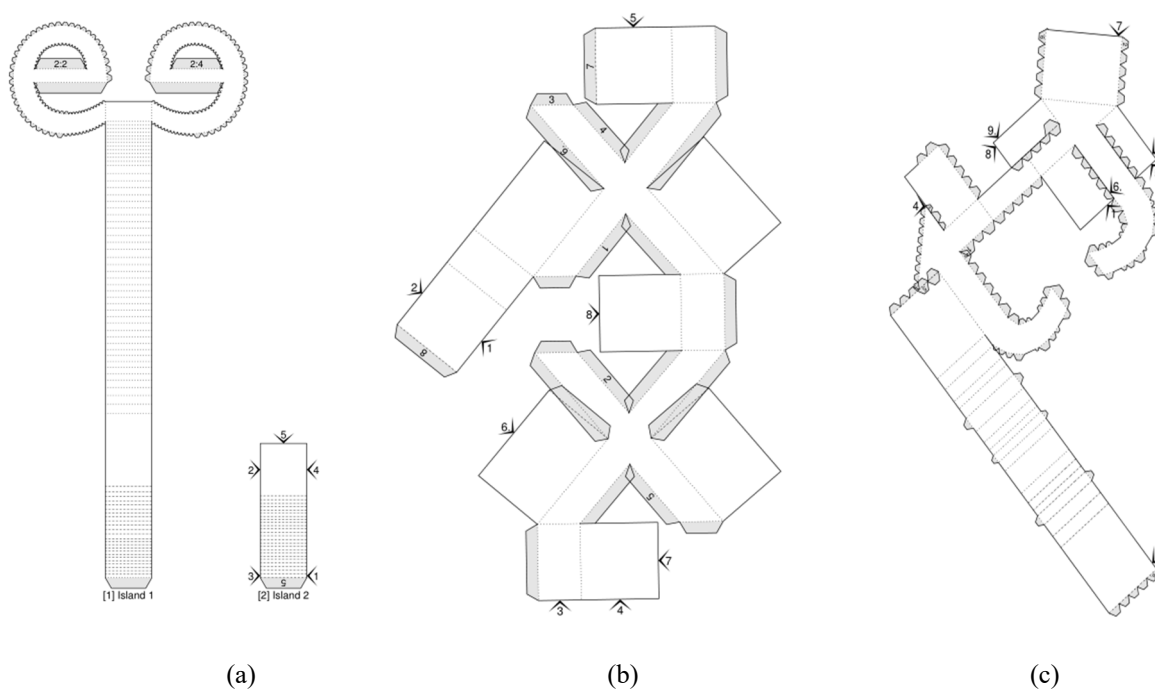


Fig. 5. Letter extension - disproportionate (a) "e", (b) "x", (c).

2.3 Three-dimensional models with a relatively complex shape

In the process of creating extensions from 3D computer models, the application Export: Paper Model tries to get the most out of the information mesh. In the presence of multiple polygons that exceed the maximum of expansion possibilities, the three-dimensional model needs to be optimized to admissibility. In order to check the performance of Blender and the application Export: Paper Model, two models with a relatively complex shape - diamond (2.3.1) and gem (2.3.2) have been parametrically developed.

2.3.1 Creating a 3D computer diamond model (Diamond) and its unfolding

Creating a 3D model of diamond in a Blender environment is a complicated process. So for convenience in the Blender Add Mesh advanced applications, there is the Add Mesh: Extra Objects app. By doing this, the geometry of the diamond becomes parametric and not conventional by manual modeling. The parameters of the newly created 3D diamond pattern are shown in Table 2.

Table 2. Parameters of the 3D model – diamond.

Operator Presets	Parameters /m
Segments	32
Girdle Radius	1
Table Radius	0.6
Crown Height	0.35
Pavilion Height	0.8

The finished 3D computer model of the diamond is shown in fig. 6 (a) in a mesh variant and fig. 6 (b) a rendered version. The resulting unfolding using the Export: Paper Model application is shown in fig.6 (c).

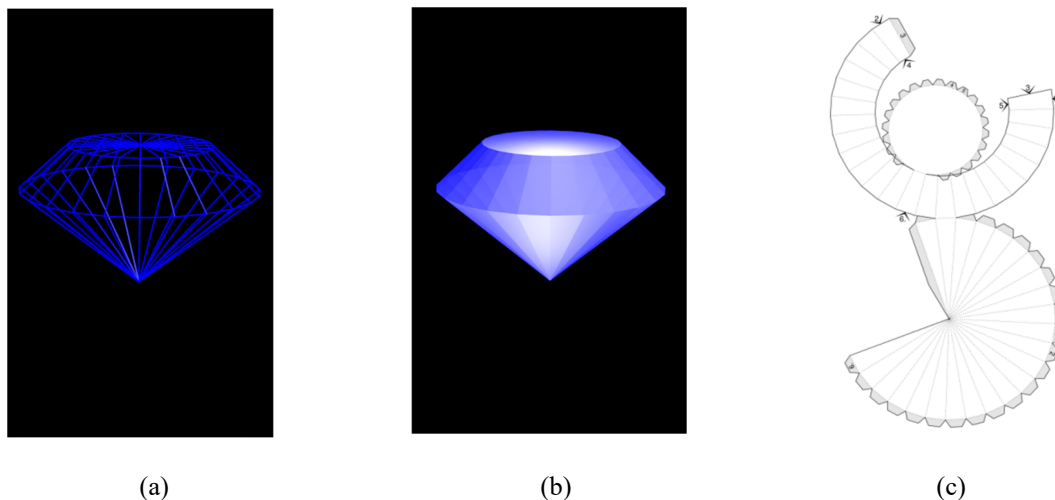


Fig. 6. 3D model of the diamond (a) mesh variant of the view, (b) rendered version of the view, (c) unfold.

2.3.2 Creating a 3D computer model of Gem and its unfolding.

The process of creating the 3D computer model of the gem is identical to the diamond, using the geometry "Gem". The parameters of the newly created 3D model of the gem are shown in Table 3.

Table 3. Parameters of the 3D model – gem.

Operator Presets	Parameters /m
Segments	8
Girdle Radius	1
Table Radius	0.6
Crown Height	0.44
Pavilion Height	0.90

The finished 3D computer model of gemstone is shown in fig. 7 (a) in a mesh variant and fig.7 (b) a rendered variant. The resulting unfolding using the Export: Paper Model application is shown in fig. 7 (c).

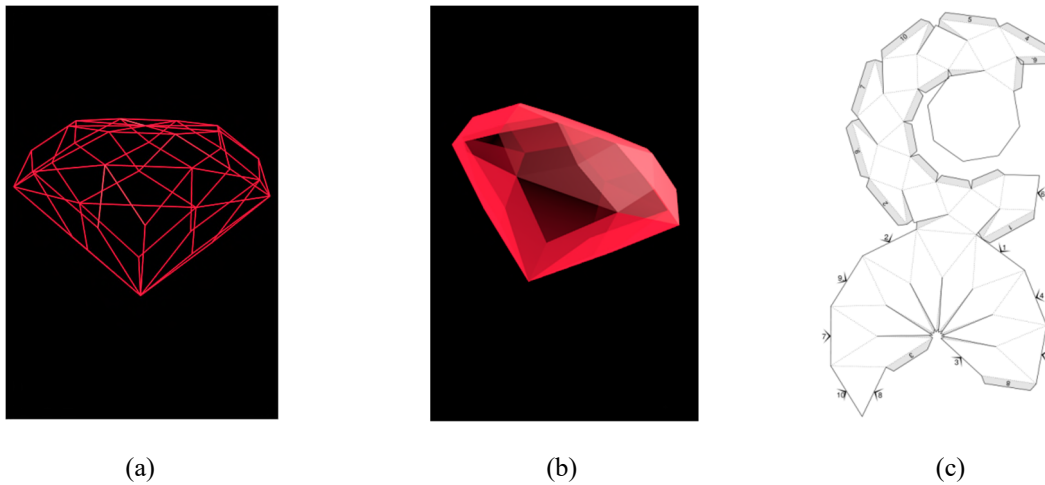


Fig. 7. 3D model of the gem (a) mesh variant of the view, (b) rendered version of the view, (c) unfold.

3 Results

The resulting unfoldings are assembled by hand or machine processing. An example of a real assembled result of the used diamond and gemstone paper samples is shown in fig. 8.

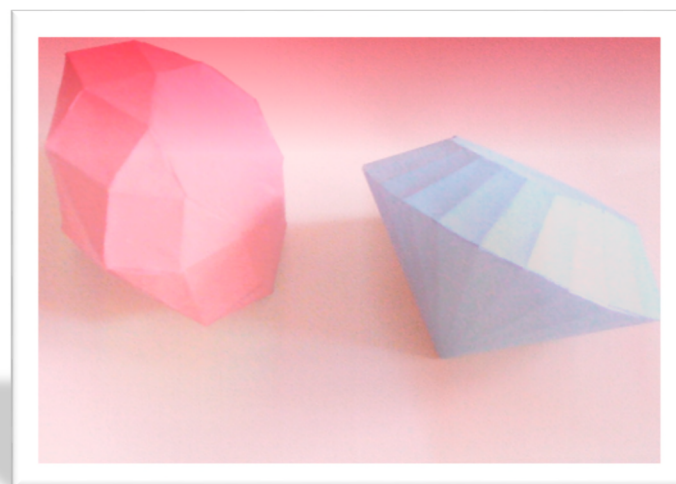


Fig. 8. The resulting assembled paper folds of diamond and gem.

4 Conclusion

In this study, the process of designing sample paper models has been closely followed using the Blender software resource, which by means of the specialized application Export: Paper Model automatically generates 3D polygonal mesh computer models. Various 3D computer models with different geometric complexity have been parametrically constructed. The opportunities used in the study prove the effectiveness of modern technological tools used to create accurate paper models.

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