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Virtual Museum of Relief Models 2.0

Summary: In 2012, the first version of Virtual Museum of Relief Models was born. The idea was based on the popular Virtual Globes Museum: an online exhibition of 3D models but presenting relief models instead of globes. It was a pilot project for developing and testing digitization and visualization techniques, processing only four models, thus not covering all types of relief model. These techniques were published earlier. The current project aims at digitizing numerous available models at the Map Collection of the Institute of Cartography and Geoinformatics, Eötvös Loránd University, (Budapest, Hungary) as it owns several unique and precious relief models.
First, we had to update and develop a trusted techniques from photographing to creating and visualizing the virtual model. The method of taking photos is similar to a photogrammetric terrain survey, but some other effects influence the process. The optical axis of the camera is perpendicular to the model surface, and the photos are taken with overlaps (depending on the diversity of the surface of the model, but the average overlapping is between 20-60%). The further influencing factors are: the size of the model, the details in the model (small text or symbols etc.), the elevation differences of the model and the material of the model. The model size determines the number of photos. If the model is small, one photo might be enough to create the texture of 3D model, but if the model is bigger, it is necessary to build an orthomosaic. If elevation differences on the model are significant, then we take additional photographs with an oblique angle at the edges of the model, taking care of the photo does not contain unsharpened parts. Some materials like some plastic or paints caused strong shimmering, therefore we applied scattered (indirect) lightning. The shimmering areas looks white or lowered parts as their environment in the 3D model.
Agisoft Metashape was used to build the model, and Cloud Compare to cut straight edges. The database of models is extended with additional descriptor metadata according to international library standards, and the old visualization method was renewed as well.

Introduction

Arnberger (1966) distinguished maps and map-like (cartographic) representations, among others the relief models are classified as the latter mentioned. The relief models are special maps, where the third dimension – the elevation is represented. The heights are mostly exaggerated to represent better the elevation differences (Pápay, 1969). The relief models show the Earth's surface illustratively, and therefore they often were applied in geography education. However, the production of the models was not easy earlier, the old and large models were often created only in one instance.

A short overview of the techniques of model making in Hungary in 20th century

The most frequently applied technique was the following before the era of plastic materials: the layers of model were cut out from veneer sheets (or plywoods) or cardboards along the contour line

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levels, and they were fixed to each other with glues and/or nails. With this method, the layers do not form continuous surface, but also a stepped surface, therefore they were smoothed with different materials, for example plaster. This method does not allow fast production, because cutting out the layers was very slow and time consuming (Balla, 1975). The first attempts at the mass-production of relief models happened with special machines – a kind of pantographs. These machines worked with electric motors and the miller head cut easily the gypsum block. To mill the next layers, the head had to be set manually. This procedure was not so precise (only 2 mm) due to the miller head size. Later, in 1970's, the polyurethane foam, the Hungarocell was applied instead of gypsum. Cutting of Hungarocell sheets did wire heated with electricity. This wire was very thin, 0.1 mm and allowed a precise cutting result of the material. Original contour lines were drawn on a transparent plastic foil, which gave the line of the cutting. The Hungarocell sheets were glued to each other, and the stepped surface was smoothed with wax and wax-like material. Alternatively, a special machine with heated wire was also developed to disappear the stepped surface. This technique was relatively fast: 0,5 m^2 size model can be finished in few hours. This method allows to create positive and negative models (Balla, 1975).

The mass production of small-scale relief models was based on the above-described process, but a new material, the "separator" plastic sheet (a kind of PVC) was applied. The cutting process is similar and at the end, a negative model was built. Into this negative one, liquid gypsum was poured, this was the positive model. After that the positive model was capable to form the thermoplastic relief models with vacuum forming (Balla, 1975, Petrov 1958).

Unfortunately, the number of publications in the topics of relief model is limited to a few articles in Hungary, therefore the authors could use only these descriptions.

About the processed models

The collection of the Map Collection at Eötvös Loránd University, Institute of Cartography and Geoinformatics has numerous relief models in various size, material and scale. There are unique rarities, especially including the large models. The authors classified the models by their material and size, and shortly described them in the following section. These models are also represented at the new website of the Virtual Museum of Relief Models.

There are six small metal models (M27–32 – catalogue number) (~15×20 cm) published by Victor von Reitzner in Wien, in the late 1880's. These terrain models represent different types of the Austrian landscape and served education purposes (Figure 1). The metal is hand-painted with 4–10 colors. Their surface is designed with different tactile textures for different landscapes (forest, farm, field, river etc.), therefore younger children or visually impaired or blind people can use to get familiar with the map features.

Figure 1. M30 hand-painted relief model made from metal

The small plaster models (M36–45) were created for students to deepen their topographic knowledge (Figure 2). These models were used earlier to learn how to interpret the contour lines of the Earth's surface. There are 10 plaster models (five different, two from each type). Their size is around 15×20 cm, and the depth is 5–8 cm, therefore at the edges some oblique view photos had to be taken.

Figure 2. M40 model made from gypsum.

There are some large size terrain models in various sizes and scales. The most of them were created for a wooden base plate, and each contour layers were cut from wood as well and fixed with glue and nails to the previous layer. A good example is the model number M91 depicted the Börzsöny–Pilis hills in Hungary (Figure 3). The upper wooden layer was painted green and the Danube blue color. The above-mentioned technique was used and developed further in the case of model M90 representing the Transdanubian Mountains (Figure 4). It is partially covered with a plaster and paper layer (smoother parts) and the higher parts are uncovered wooden layers. The dark and light brown coloring makes the difference between the two parts. Mátra Mountain (M95, Figure 5) and Sátor Hegyek (Tokaj–Eperjes Hills, M93) were made with same techniques: they have a colored hypsometric base map, which contains rivers, built-up areas and their names, roads, railways and forest as well.

Figure 3. Börzsöny and Pilis embrace the Danube (M91)

Figure 4. A detail from the Transdanubian Mountains (M90) relief model. The lower parts are covered with plaster, and the mountain parts are uncovered wooden layers.

Figure 5. Relief model of Mátra Mountain (M95).

In the collection, there are small scale pure topographical relief models with minimal or no coloring and without any other map features about Europe (M94), the Carpathian Basin (M97), Hungary (M92). The Carpathian Basin (M88) also appeared in another model in 72×109 cm size covered by a hypsometric tint. The map contains the rivers, the borders and the main cities. The model was

created by the company Fővárosi Neon Tanszerosztálya in 1950's years (the exact date is not written on the model).
The two largest model of the collection are a Budapest terrain map 242×178 cm made by Lajos Tiderle in 1957 (M100) and a Hungary terrain map around 300×250 cm with physical map content (M89).
The "youngest" large models are the Lake Balaton (Figure 6, M98) – its size is 175×86 cm made by Kartográfiai Vállalat (Cartographia Co.) in 1990, and Tihany relief map (77×105 cm, M99) maps made around 1990 by Lajos Tiderle at ELTE. They were made from plastic plate while using a negative printing form. The printing form of Lake Balaton is also can be found in the digital collection as well.

Figure 6. Lake Balaton is made from plastic (M98)

The Map Collection has several plastic models. The most of them was made in the last 60 years. The digitization of these models was maybe the biggest challenge, because of their material. The plastic plate caused shimmering on their surface, and therefore the authors worked with indirect (scattered) lightning of the room instead of direct lightning. These models are rather small or medium size. The maps are so detailed as a paper map, and the text is written in small font size, which made digitization even more difficult. Recently, the users can be seen five models in the museum, the oldest is Marocco (1971, Figure 7) and Bulgaria (1972).

Figure 7: Relief model of Marocco from plastic sheet

The first version of the Museum

The first version of the Virtual Museum of Relief Models was created in 2012 by János Mészáros and Mátyás Gede (2012). Four relief models were digitized including a plastic model, two small metal models, and a large-size relief model of Hungary. The small models were photographed using same techniques as in VGM: the camera and the model's plane closed 45° and 8 photos were taken around the small models. This technique did not eliminate the shining parts of the model. Building the 3D model, Hypr3D – a free online tool was used. The mosaic-like texture was replaced with a corrected one. The 3D visualization on the website is based on X3DOM JavaScript Library in X3D format (Figure 8).

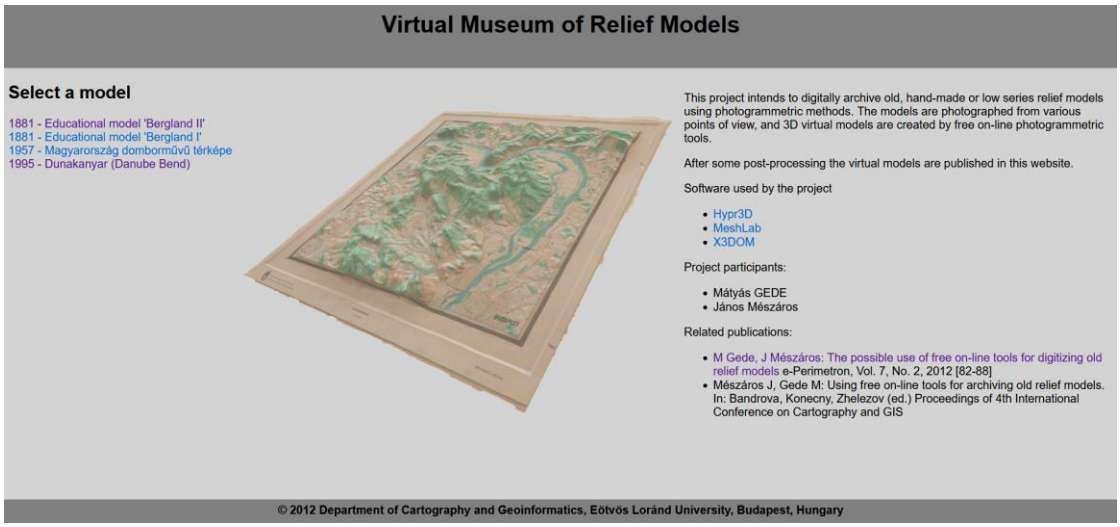

Figure 8. The old website of the VMRM

The renewed museum

Due to the re-systematization of the Map Collection the digitization work of models was continued. The first step is to take photos. The novel photographing technique of relief models is based on a traditional photogrammetric survey: the photos have minimum 20% overlap between two pictures in rows and columns as well, but sometimes 60% overlap is necessary, if the model surface is smooth. The angle between the model's plane and the camera closes ~90°. If the model has significant elevation differences (depth) close to the edges (more than 3 cm), or it has a thick frame, the authors took pictures with oblique view (45-60°) around the models considering these images do not cover large areas. In oblique view, the further parts from the camera can be dim. The lightning condition in the room was important as well: scattered light decreased the shimmering parts on the model's surface. Shimmering is undesirable, because these parts look white in the photos. The shimmering is strongly depending on the material or painting of the model: the most difficult was working with plastic models.

The number of the photos depends on the size of the models: smaller (10–20×20–30 cm) models need to take 25–30 images. Medium size models (30–60×30–60 cm) were built from 30-50 images, and large size models (with longer than 50 cm side length) are generated from 70–100 pictures. To build the textured 3D model Agisoft MetaShape was used. In MetaShape, it is possible to make an orthomosaic texture or use only one image for the texture of the model. The latter one was applied in the case of small and medium size models, if the model has minor depth (for example plaster terrain models has significant depth, they cannot be completely textured from all sides).

The digital models were compiled in Agisoft MetaShape. While the authors took photographs, the environment of the model had to be recorded. Especially had to be paid attention to the edges and corners of the relief model, they had to be included in two or three photos to avoid the missing edges and corners of the digital model. After that, the environment had to be removed from the digital relief model. The edges should be straight after cutting, but MetaShape cannot cut the triangles of the mesh into two halves, therefore the edge follows the triangles (it is not really straight). Therefore, Cloud Compare was used to crop the model edges to straight. The models were exported in OBJ format.

Until the authors found the final solution, three visualization methods were tested. First, the X3D format was tried out with X3DOM JavaScript Library, but the larger models cannot be shown in this format. The OBJ format has the same problem with X3DOM, therefore threeJS Library was tried out. The large models worked with this Library, but the zooming cannot be optimized for large and small models as well.

Finally, authors choose the Sketchfab online 3D visualization tool to represent the relief models on the website. Sketchfab grants a fast and easy-to-use environment to view the 3D models on the website. It has free and business accounts. The free version has some limitations: the size of the uploaded file cannot exceed the 100 MB limit per model. If the users do not want to share and make the model downloadable for other users, the maximum number of uploaded models is 10 per month. These models can be easily embedded to any website, with the embedded code generated via Sketchfab. The authors recorded this code to the database.

The new VMRM website begins with the list of available 3D models after the users enter in the virtual museum. Every model has its own profile, where users can see the 3D relief model and its title, publisher/creator, publishing date, material, the represented area and scale, and the real size of the model (Figure 9). The VMRM is available at http://terkeptar.elte.hu/vmrm/

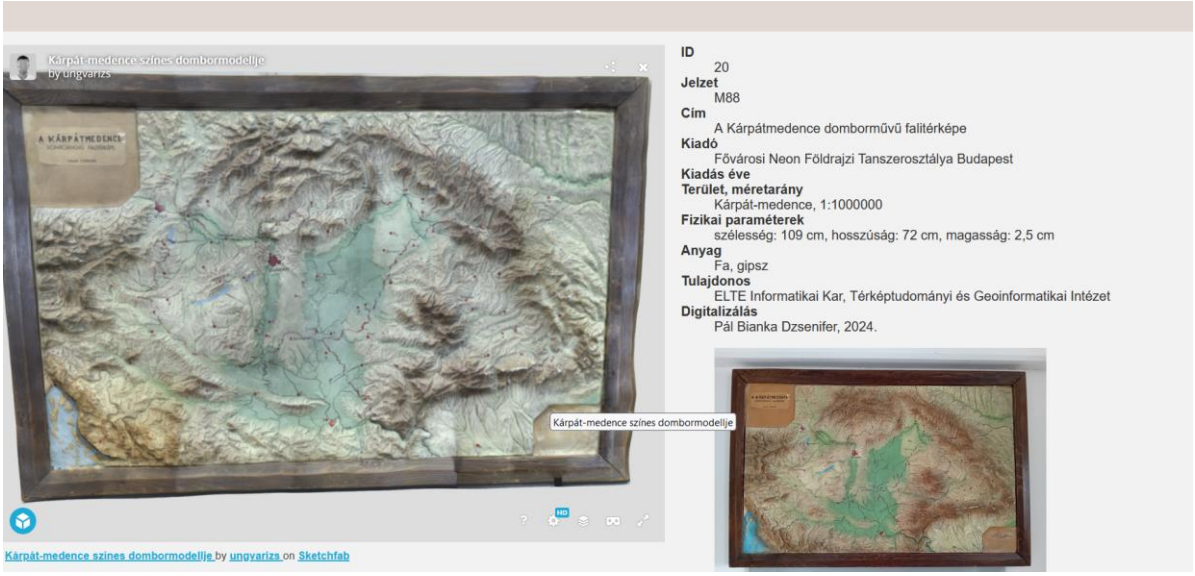

Figure 9. M88 Relief model's page on the website.

Conclusion

The Virtual Museum of Relief Models is now renewed, and new relief models were introduced in the Museum. Currently, 20 digital models are uploaded in the virtual collection, and 12 more models are processed, and waiting for uploading.

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