The image processing for creating 3D model in teaching computer science

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Abstract – The subject of computer science can be implemented at every level of education. It offers a creative space for the modernization of education. The image processing and the creation of 2D and 3D models are an actual problem in computer science. The digital technologies and modern methods are useful in solving many tasks in this area. The paper presents procedures which are easy to implement in the teaching of computer science at secondary schools. We will focus on the creation of real spatial models of small objects. The mastering the curriculum is highly supported by the active involvement of students in creation of models. We have designed a teaching module for inclusion, the creation of a real model in the subject’s content, by combination of project and problem-based teaching. Students learn by actively participating in solving partial problems. They can incorporate into the solution of real projects on the chosen topic. The project method allows students to work in groups and solve a complex practical tasks by practical activities. Our aim is to motivate students to mastering the curriculum via an active learning method “learning by doing”, by represents a real problem from everyday life, by using modern (mobile) technologies. The ability to collaborate, learn by discovering and exploring influences the development of a learning strategies.

Keywords – Computer Science, Education, Image Processing, 3D Model, Creation

I. INTRODUCTION

We live in a knowledge society. With modern technologies we can process more information in a shorter time. Within the subject of computer science, we can use activating methods and work projects in classroom. Activating methods create space and opportunities for the modern constructivist learning process. We can show the idea of how adults actually use computers at work for implementing solutions for real problems of everyday life. Students can develop critical and responsible thinking and decision-making. The subject of computer science can be implemented at every level of education. It offers a creative space for the modernization of education. The ability to collaborate, learn by discovering and exploring influences the development of a learning strategies. Above all, students should develop their cooperation and communication skills. It is important that they learn to work together in groups to solve problems, be able to prepare work plans, specify subproblems, collect results and compile
them into an overall solution, as well as the need for self-education in further [1, 6-10, 12-15].

II. CONTENT AND ORGANIZATIONAL FORMS OF COMPUTER SCIENCE AT SECONDARY SCHOOLS IN SLOVAKIA

According to the documents of the International Standardized Classification of Education (ISCED), the content of the subject of computer science for secondary schools is mainly aimed at acquainting students with various types of data, their collection, storage, display, processing and presentation. It is important to acquire skills to be able formulate the problem, as well as to obtain information from appropriate sources, to find a solution and contexts. The students' effort should be primarily focusing on logical thinking, developing the creativity [1, 2].

The project method allows students to work in groups and solve a complex practical tasks by practical activities (problem, topic) associated with real life. The goal is to create an adequate product - project. The process of the project can be divided into several working phases. At the beginning, it is important to determine the goal. At the next phase is created a plan for the solution (responsibilities, work plan, method of presentation of results will be divided). At the end is the realization of the plan and publication of the project results.

In the next chapters we would like to present a teaching module for the introduction of modern technologies for image processing and creating a real model.

III. MATERIALS AND METHODS

Nowadays, many students already have a smart mobile phone capable of creating simple videos. We will use captured videos and photogrammetry procedures to create models. The quality of the created model depends on the used software. We can also influence it by the way of obtaining the video sequence. It is required that the video should be created rather slowly, and not at a rapid pace. The subject must be visible from all sides (as well as from the top or bottom). The overlap of individual frame obtained from the captured video should be at least 2/3.

Software for image processing: There are several software products for measurement and modelling of the real-world through photographs. Among the paid products we would recommend the software Agisoft (known as Agisoft Metashape). We used the photogrammetric software for free. Pix4D mapper Pro mainly enables desktop and cloud image processing, generation of 3D Point Clouds and their classification, generation of 3D textured models as well as 2D measurements and 2D vector outputs [3, 4]. When importing a video, the software first requires us to set the number of frames (it is automatically selects from the video according to fps. On the Fig. 1 we can see the individual frames that the software selected from the imported video. Using photogrammetry procedures, the software processes the so-called Tie Points (from them the Point Clouds will be created). We can see this in Fig. 2.

Teaching module design: Method used during the teaching module is project based learning. Organizational form of education used during the teaching module is teamwork. Didactic tools: camera, mobile, software for create 3D model.
(Pix4Dmapper Pro), computer (minimum requirement: 12 core processor, 32 GB RAM). The final product is a digital 3D model of a selected object.

**Working phase description:** The first step is to capture the subject (we recommend choosing a simple square object) by creating a video at a slow pace. During the shooting session check the sharpness of the images, as well as selecting the image stabilization function (video cameras and camcorders, as well as mobile phones already have this functions). We capture the object with the camera gradually from all sides by moving around the object (from the side, and from the top at an angle of 45°).

At the next working phase we can use the appropriate software to create a 3D model of the captured object (Pix4Dmapper Pro). We need to import video and set number of images that the software automatically selects from the video based on the fps. Subsequently, the software processes Tie Points. From those is created Point Clouds. The model of the object is created by using Triangle meshes. It doesn't have to be always strictly perfect. It often needs to be adjusted by manually removing the Tie Points and re-mashing. However, we must take into account that significant trimming of Tie Points can lead to the loss of the integrity of the object.

![Fig. 3 Created model from 500 photos and the modified model (on the right)](image)

If we reduce the number of photos/selected video frames to 500 while importing the video, then the model created by the software will still be acceptable quality for the overall modification of the 3D model [5].

![Fig. 4 Created model from 50 photos and the modified model (on the right)](image)

If we continue in reduce the number of photos, we can see in the Table 1 that the number of photos 100 appears to be insufficient to modify the 3D model. There is a risk of the so-called surface ripple effect (see on the Fig. 4).

<table>
<thead>
<tr>
<th>Number of photos</th>
<th>1000</th>
<th>500</th>
<th>250</th>
<th>100</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of model</td>
<td>very good</td>
<td>enough good</td>
<td>good</td>
<td>with errors</td>
<td>very bad</td>
</tr>
<tr>
<td>Quality of modified 3D model</td>
<td>very good</td>
<td>very good</td>
<td>good</td>
<td>with risk of surface ripple</td>
<td>incomplete</td>
</tr>
<tr>
<td>Time for creation</td>
<td>10-12 hours</td>
<td>80 min</td>
<td>50 min</td>
<td>25-30 min</td>
<td>10 min</td>
</tr>
</tbody>
</table>

For smaller objects (the size of a smaller box or like) it is sufficient to set the number of photos in the range of 1000 to 250. It is enough for ensure good quality of the created 3D model.

**IV. RESULTS**

In the article we have shown that the creation of models is in a given way and quite effectively implementable into the teaching process. We can state that the given procedures are well applicable in secondary schools. Our practical experience from observation is well summarized by Table 1. We want to point out how the number of photos obtained from the captured video affects the quality of the 3D model.

**V. CONCLUSION**

Currently, it is probably impossible and unimaginable to exclude elements of ICT from the educational process. The creation of 3D models has become very popular nowadays. Acquiring photos and videos in today's digital age is not a challenge, nor is the cost of the required software for processing them. The development of computer
technology as well as the increase in computing power undoubtedly contributed to this. The results obtained may not only serve as a compulsory school task. It have other practical significance, such as 3D model printing, model archiving and the like.

REFERENCES


