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EXPLORING THE VERSATILITY OF OPEN-SOURCE SOFTWARE FOR INDUSTRIAL IMAGE PROCESSING: A CASE STUDY

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Introduction

Utilization of 3D models for manufacturing processes has been a technical method of choice in the past decades, and at present it still remains a highly relevant approach (Chlebus & Krot, 2016). Currently, there are multiple different ways of obtaining a three-dimensional model such as parametric or box modeling, sculpting, or optical scanning (Rusinkiewicz et al., 2002; Pollefeys , 2004). In general, entry data containing information such as dimensions, surface characteristics, or constraints are needed to begin the creation of the model (Rivers at al., 2010). The practice of using visual cues to sketch the base model and then continue further with its refinement can often be a viable solution, especially if the source material is of poor quality or a highly detailed and precise model is needed for the application (Remondino & El-Hakim, 2006; Chen at al., 2003). This is especially important for high-precision industrial manufacturing methods such as laser beam machining. However, in some cases using a highly detailed model can be an issue due to drawbacks when it comes to computation time resulting from a high number of polygons requiring processing as well as large file size (Bernardini & Rushmeier, 2002). Therefore, adequately adapting both the source images and the final model is a much-needed step in the preparation for the subsequent manufacturing process, as it can significantly influence the resulting quality an accuracy.

Problem Description

Innovative application of Blender was examined, a highly advanced and robust open-source software tool specifically engineered for the complex creation and editing of three-dimensional data, which can also facilitate the development of reliefs derived from images captured digitally via a camera. Following this preliminary phase, the prepared relief is subsequently utilized to generate the precise CNC paths that are implemented for laser micromachining and additive manufacturing processes. Thereafter, this generated data is employed in the fabrication of samples to evaluate the appropriateness of the constructed three-dimensional relief.

Methods

Source image in the form of a digital photograph was taken and then edited in GNU Image Manipulation Program, where it was desaturated and separated into layers to produce initial height map. This image was then used to create 3D model by displacement of subdivided mesh. Further editing of the model by means of sculpting was carried out to create additional details and improve overall the quality of the model. Afterwards, the modified model was used to render out a high resolution height map, which can be used for manufacturing by laser beam machining or other techniques.

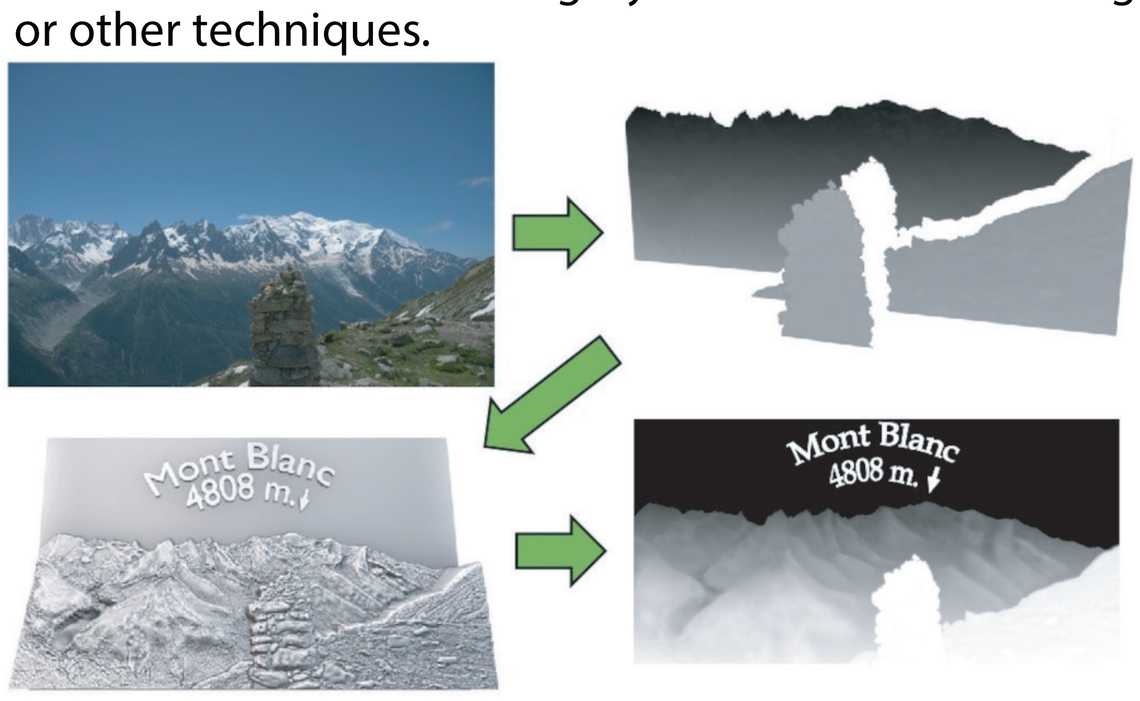

Figure 1
Process of preparing the height map

Results

A successful retention of small-scale visual details from the original photograph was achieved. However, the overall perceived depth of the relief was somewhat limited, which is expected due to the differences between the two-dimensional height map representation and the physical depth achieved through laser micromachining. Further refinement of the machining parameters could enhance the depth effect, allowing for a more pronounced three-dimensional appearance that better captures the original photograph's essence. Figure 2 shows a manufactured 3D relief. It can be seen that there remain parts of the material unaffected by the laser beam, which is due to the high sensitivity of the software to the color profile of the depth map. Having set too high cutoff for the white color resulted in the affected machined surface being incomplete. This error underlines the importance of adjusting the black and white levels of the imported height map in order to produce desired result.

Figure 2
Result of laser micromachining

The 3D printing of the relief using the MARKETBOT Replicator 2x produced a result that showed some visual artifacts. The printed output exhibited noticeable limitations in both quality and depth, impacting its overall appearance. To address these shortcomings, it is crucial to investigate and optimize the 3D printing process parameters. Adjustments in temperature, speed, and material could enhance the final product's detail retention. Additionally, reconsidering the design of the relief itself may also contribute to improved results. By refining both the printing techniques and the relief design, there is potential for a more visually appealing and detailed outcome. This dual approach could significantly elevate the quality of future 3D relief productions. Ultimately, striving for these improvements is essential for achieving better print results.

Figure 3
Result of 3D printing

Figure 3 shows a 3D printed relief created from PLA plastic material, showcasing noticeable imperfections that highlight the limitations of the printing process. This is in part the result of the need to simplify the mesh density of the 3D model, since the 3D printer slicer software had issues processing the high polygon density of the sculpted model.

Discussion / Conclusion

The conclusion highlights the successful translation of the digital image into tangible 3D relief using Blender free software, sophisticated image processing and 3D modelling. Utilizing laser micromachining process demonstrates the ability to preserve the intricate details derived from the original photograph. While the results demonstrate the effectiveness of the process, they also reveal significant limitations in the depth and quality of the 3D printed relief. The perceived depth of the relief, while retaining small visual details, was considerably limited. Factors such as temperature, printing speed and material selection play a significant role in determining the quality of the final product and the retention of detail. By conducting systematic experiments to fine tune these variables, it may be possible to achieve a finer and more accurate representation of the intended design. In addition, a thorough rethinking of the relief design itself could yield improvements in visual appeal and detail, ensuring that the final product is more in keeping with the artist's or designer's vision.

Optimizing 3D printing parameters and reevaluating the relief design is important to improve future results. In conclusion, while the study successfully demonstrates the viability of using open source software to generate high quality industrial applications, it also highlights the need for continuous improvement and optimization. By addressing the identified limitations and taking advantage of technological advances, future projects can achieve a higher level of accuracy and artistry in the production of 3D reliefs. This constant pursuit of excellence not only improves the practical applications of these techniques, but also contributes to the broader field of digital fabrication, paving the way for innovative solutions in a variety of industries.

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