GALLERY PAINTINGS FOR BLIND AND VISUALLY IMPAIRED

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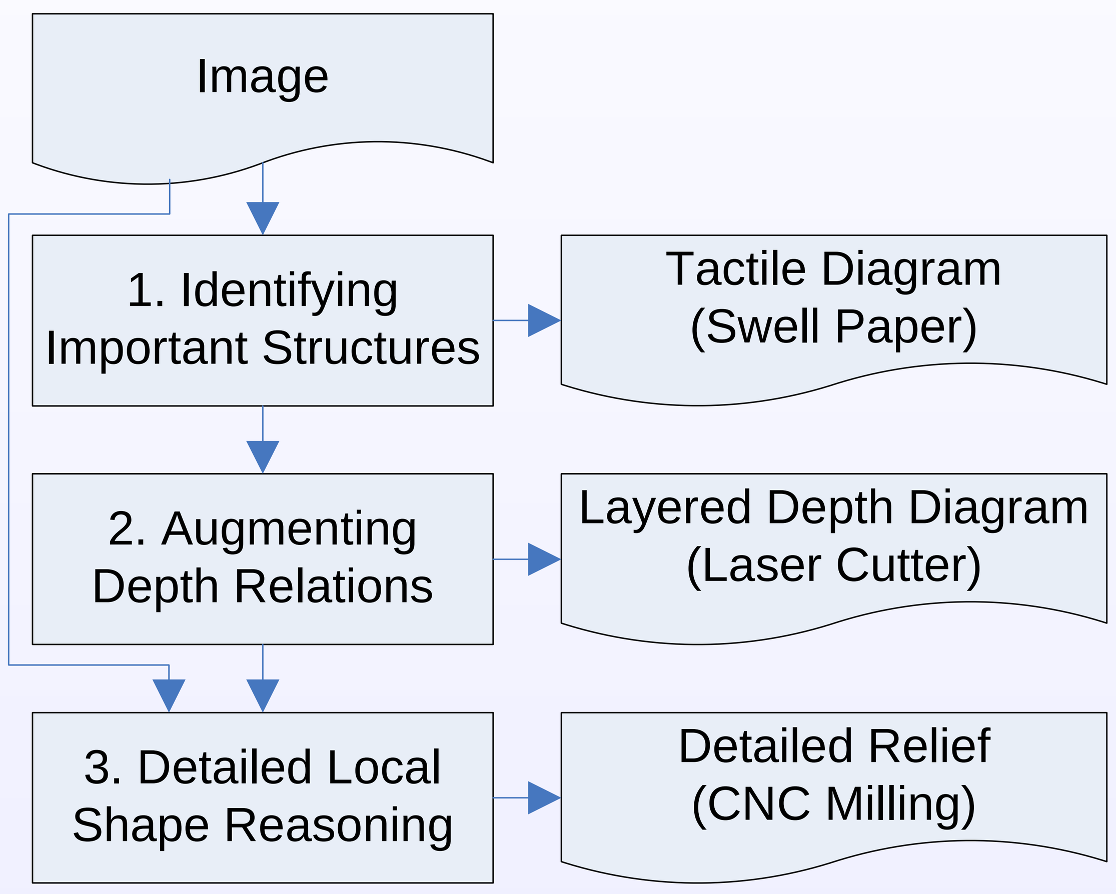
Abstract

The goal of this project is to transfer paintings into tactile representations. This will make two-dimensional art originally intended for sighted people accessible for blind and visually impaired people. We have developed a semi-automatic process that converts images into three tactile forms of increasing complexity, suitable to be produced on rapid prototyping machines: tactile diagrams on swell paper, laser-cutted layered depth diagrams, and CNC-milled detailed reliefs.

Process

The conversion process consists of three consecutive steps, each creating the data necessary for the production of one type of tactile media. This incremental process enables us to evaluate the—easier to create and thus cheaper—prototypes of earlier steps, before continuing with the next step.



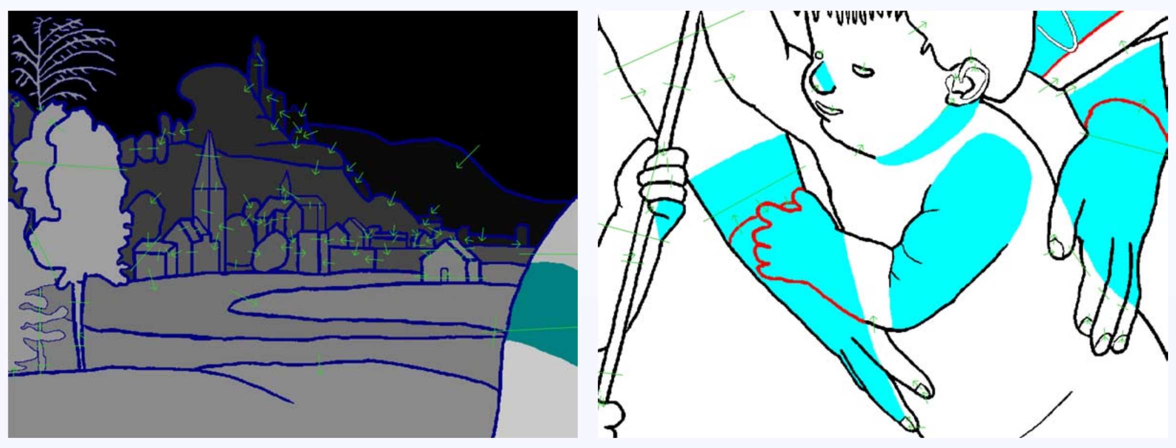
1. Identifying Structures

To reduce the complexity of the images to the most important structures, we convert them into line drawings. Important lines mostly correspond to edges both in the image and in the painted objects, and are potential boundaries of semantic entities. Edge detection techniques produce reasonably good results that can be manually refined to obtain drawings of higher quality. The output of this process, automatically vectorized and augmented with different line types and fill patterns, can be directly printed on swell paper as tactile diagrams [1].

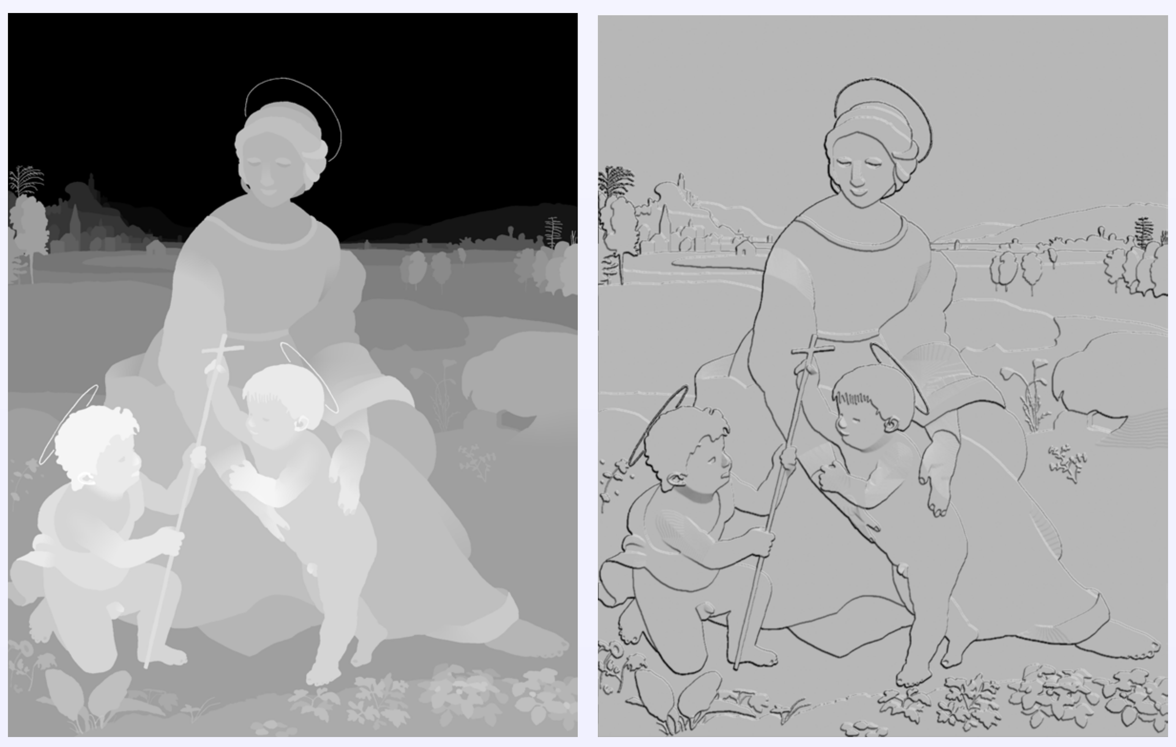
Left: Original image. Right: Line drawing.

2. Depth Relations

Image comprehension can be significantly improved by conveying the depth of the objects as arranged in the painting. Assigning absolute depth is virtually impossible for computers since this task requires full image understanding, and is even hard for humans. We developed an intuitive user interface where the user assigns easy-to-see depth relations between objects by drawing arrows for "in-front-of" and lines for "same-height" relations. An efficient graph labeling algorithm solves the resulting inequality graph and assigns each segmented entity of step 1 a discrete depth value. Unsolvable loops may occur at complex interactions (e.g. the hands in the example) and situations may occur where gradual depth changes are more appropriate than depth discontinuities (e.g. neck and nose). These can be solved by allowing areas to be bent (areas marked in cyan), in which neighboring depth values are interpolated. The resulting discrete depth map is automatically converted into layers to be laser-cut out of flexible plastic sheets and assembled on top of each other.



Left: Assigning depth relations. Green arrows denote "in-front-of" relations, green lines "same-height" relations.
Right: Areas to be bent.



Left: Discrete depth map.
Right: Rendering of layered depth diagram.

References

[1] E., Salzhauer Axel, N., Sobol Levent: Art beyond sight: a resource guide to art, creativity, and visual impairment, New York: AFB Press, 2003.

3. Local Shape Reasoning

The use of shape from shading techniques is not feasible, since the constant material assumption will be often violated, shadows and interreflections may exist, and the illumination cannot be assumed to be painted physically correct. However, since typical renaissance paintings are quite vividly painted, local shape reasoning techniques—as used by 3D artists for displacement map creation—can be adapted. Customizable spectral filtering produces reasonably good depth images containing all the fine detail. While the inter-object depth relations are—as expected—useless, the inside structures of objects are plausibly recovered. Combining this detailed depth image with the coarse but globally correct image of step 2 results in a detailed and globally correct relief that can be produced with CNC mills or 3D printers.

Left: Local depth reasoning output.
Right: Rendering of local depth reasoning. Note e.g. the sky in front of Madonna.

Left: Combination of discrete depth map and local depth reasoning.
Right: Rendering of resulting detailed relief.

Future Work

After an evaluation by experts and blind test users, we will refine the process and investigate possibilities for further automation.

Acknowledgements

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The painting is "Madonna im Grünen" by Raffaello Santi, 1505.