Tactile 3D-Graphics for Blind People

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Abstract

For blind people text and images on web pages can be displayed on tactile graphics displays. In previous publications we have presented a tactile web browser that can handle mathematical expressions, as well as two-dimensional graphics. In this paper we propose a method that enables blind people to access three-dimensional graphics on our tactile graphics display. To implement this method two steps are necessary. In the first step the feature lines of the 3D-model that represent the edges of the entire objects are extracted. In the second step the extracted feature lines are rendered as line strokes on the tactile graphics display. To explore the model the user can interactively rotate and zoom. For our method we present use cases and the first experiences that some blind people have made in exploring 3D-graphics on our tactile graphics display.

1. Introduction

More and more information can only be found on web pages. In previous publications we have presented a tactile web browser that can handle mathematical expressions, as well as two-dimensional graphics [7, 8]. This enables blind people to access web pages with graphical information for their everyday life, e.g. diagrams or maps. Especially in scientific education it is necessary to have access to formulas, images, and diagrams.

For the future it could be interesting for blind people to get access to three-dimensional information. The 3D-models could be published on web pages from educational institutions, furnishing houses, city information systems, cartographic services, etc. For blind people it might be helpful to get a first impression on how their desired furniture is shaped (e.g. armchairs, beds, cupboards, etc.) before they visit furnishing houses or to get an impression on the topological information and sights from maps before they go for hiking or sightseeing to a region or a city. In this paper we propose a method that enables blind people to access three-dimensional graphics on tactile graphics displays. Furthermore the 3D-models can be interactively rotated and zoomed.

Some related work has been done in the presentation of 3D information to blind people by Yoshihiro Kawai and Fumiaki Tomita. They have presented an interactive tactile display system that was able to support visually disabled people in recognizing 3D objects [3]. Martin Kurze has done some work in the recognition of three-dimensional objects by blind people [4, 5]. An overview on methods in tactile 3D-graphics is given by Kevin Christian [1].

The rest of this paper is structured as follows: The next section describes how 3D-graphics are presented on tactile graphics displays. Section 3 shows how 3D-models are transformed into a tactile representation. The paper ends with a discussion and gives an outlook to future work.

2. Tactile 3D-Graphics

To present graphical information to blind people we use the tactile graphics display from Metec (figure 1). The device has a display area of 37x19 cm and 120x60 pins. Since this tactile graphics display can only represent two states per pin (pin up or down), images have to be reduced to monochrome colors.

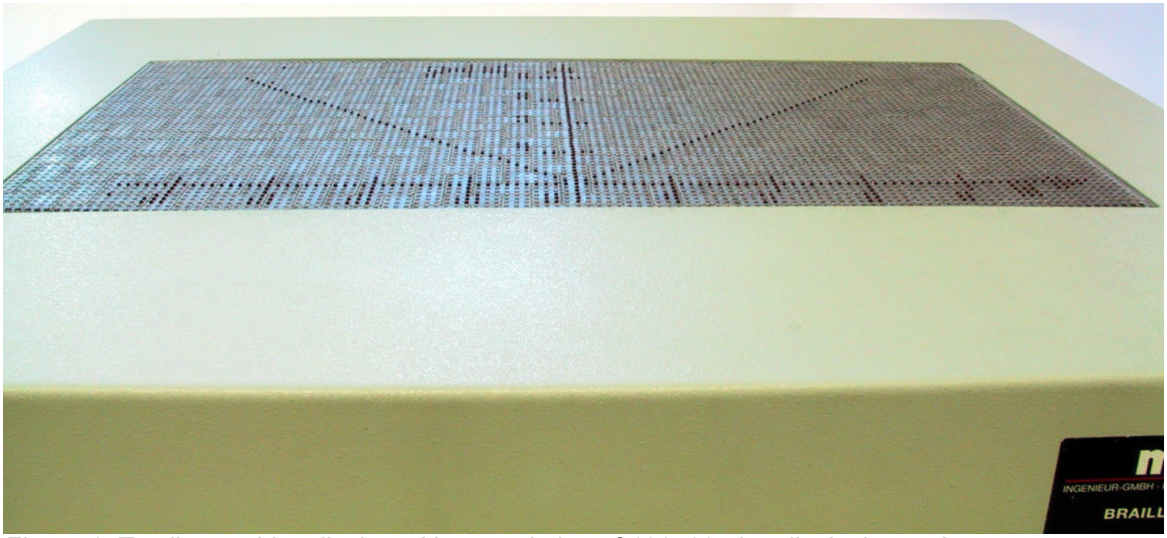

Figure 1: Tactile graphics display with a resolution of 120x60 pins displaying an image

In previous publications we have presented a tactile web browser that can handle mathematical expressions, as well as two-dimensional graphics [6, 7, 8]. This tactile web browser can present standard web pages, raster images, two-dimensional vector graphics that are in the Scalable Vector Graphics (SVG) format, and mathematical expressions in MathML. As an extension to the tactile web browser we have implemented an exploration mode for three-dimensional graphics. The 3D-models are presented on the tactile graphic display in a way that the feature lines including the view dependent silhouette lines are represented as edges.

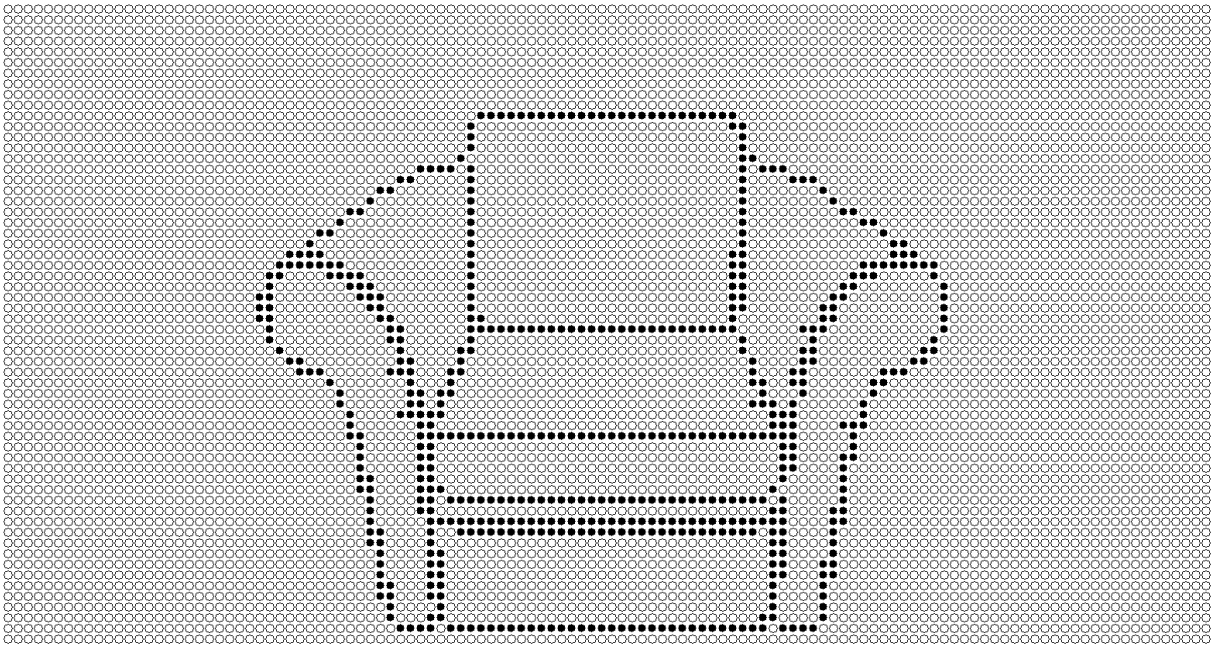

Figure 2: Tactile representation of an armchair

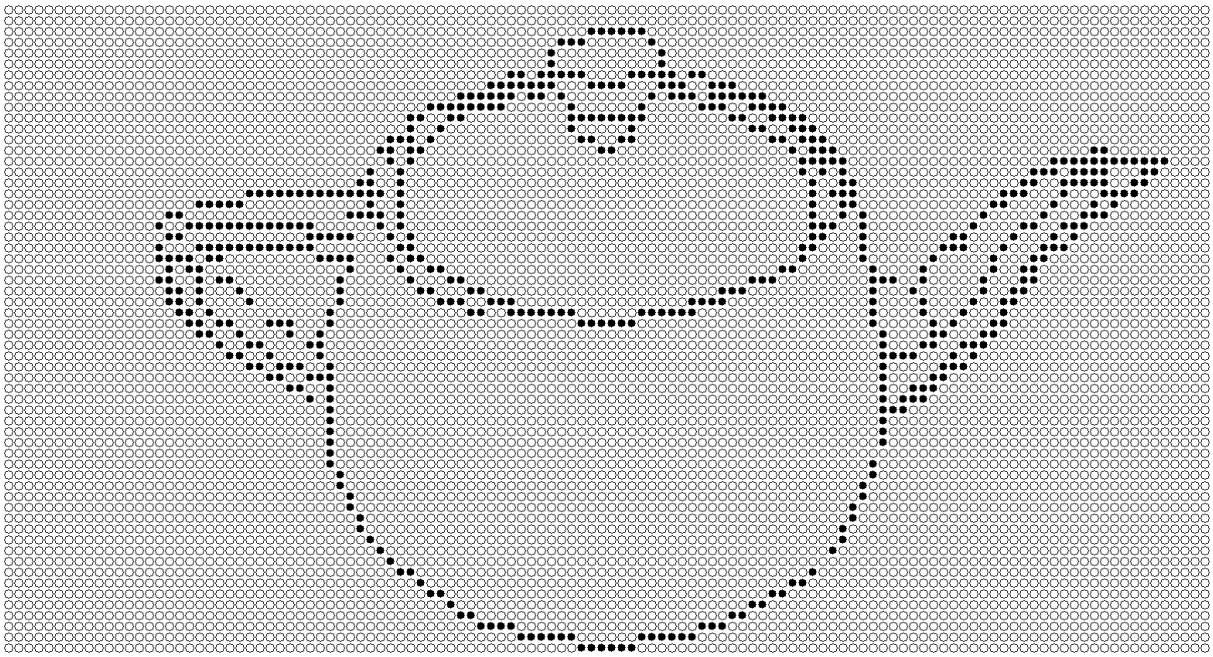

Figure 3: Tactile representation of an utah teapot

Figure 2 and figure 3 show results on a simulation of the tactile graphics display. To explore the 3D-model the users can interactively rotate and zoom. In the current version the numeric keypad of the keyboard is used to control the transformations. The objects can be rotated around all three axes. To explore an object from a defined viewpoint the user can rotate in an arbitrary way and after that reset the viewpoint back again.

3. 3D-Model Transformation

For our method to present three-dimensional graphics to blind people a transformation is needed that extracts the feature lines. Joachim Diepstraten, Martin Görke, and Thomas Ertl have proposed an approach on how to extract the feature lines of a 3D-model [2]. The feature lines that represent the edges of the object are distinguished in boundaries, ridges, valleys, and silhouettes lines by them. These feature lines are extracted and converted into line strokes. The result of this transformation is shown in figure 4 and 5. Finally the line strokes have to be rendered on the tactile graphics display.

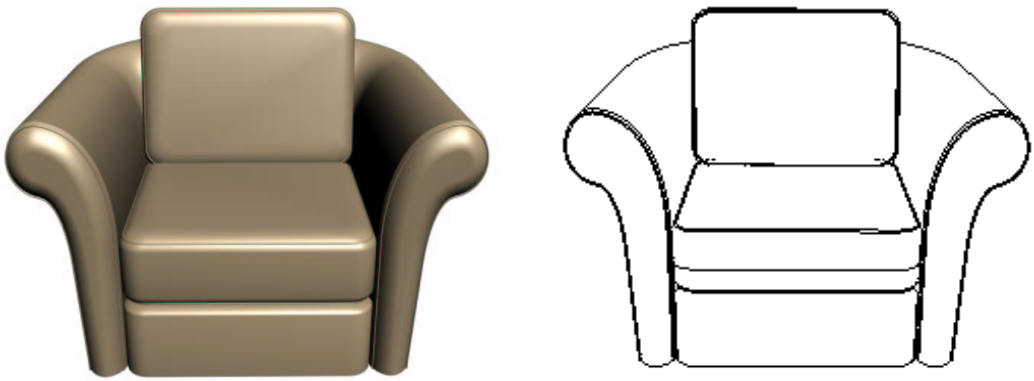

Figure 4: Original 3D-model and result of the feature line extraction of a armchair

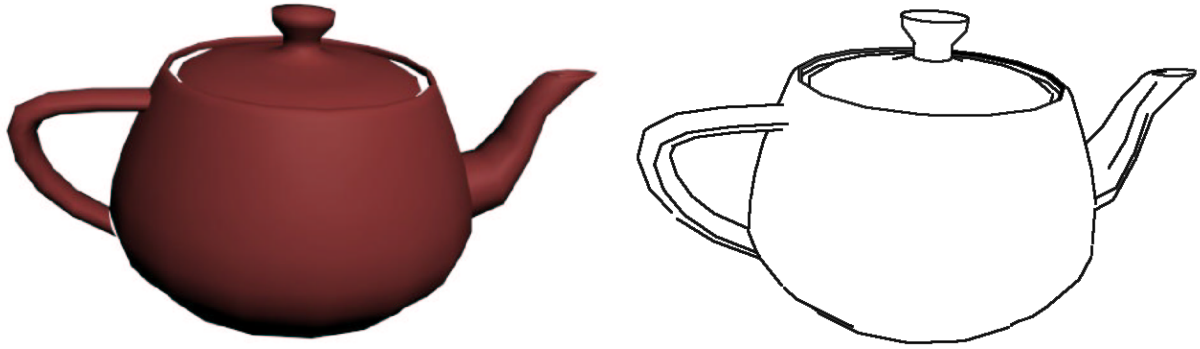

Figure 5: Original 3D-model and result of the feature line extraction of an utah teapot

For the interactive control of the presented 3D-model the input events have to be handled. For each rotation or zooming request the viewpoint on the 3D-model has to be recalculated. In the case of a reset request the viewpoint is reset to the predefined viewpoint. Then the new feature lines are extracted and rendered on the tactile graphics display as line strokes.

4. Results and Outlook

In this paper we have proposed an approach to make three-dimensional graphics accessible to blind people. Therefore we extract the feature lines to render the scene on a tactile graphics display. For the feature lines extraction we use a method from Diepstraten et. al. [2]. The extracted feature lines are rendered as line strokes on the tactile graphics display. To explore the model the users can interactively rotate, zoom and reset the viewpoint.

In a preliminary evaluation with a just few blind people we found out that the exploration of 3D-objects is a challenging task. The change of the feature lines from every viewpoint is confusing the users tremendously. Thus they were not able to find out what kind of object they are exploring when they start at an arbitrary viewpoint. But if the starting viewpoint has been e.g. the side view or the top view, the exploration of even details in the 3D-scene were possible. Our test persons where persons with acquired blindness. For them it might be easier to imagine the 3D to 2D perspective projection of the scene because they were used to this as sighted people.

When we take a look on the research of Martin Kurze [5] we realize that blind people could experience space in a different way than sighted people do. Our presentation uses perspective drawing that is not common to all blind people. One future work will be to integrate a nonlinear projection into our presentation method. The nonlinearity of cause should be adaptable to the perception of the individual space experience. The control of the rotation and zooming could be more intuitive if we would use a Joystick, a SpaceMouse, a Phantom or a footpanel instead of the keyboard.

References

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