Large-scale transformation optics — supplementary information

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USING DR TIM TO REPEAT AND MODIFY THE SIMULATIONS

All simulations shown in the paper were performed with our custom ray tracer Dr TIM [1, 2] (Fig. 1). With the instructions provided in this section, the reader should be able to run all simulations described in this paper, shown again in Fig. 2. Further information on how to use Dr TIM can be found in the user guide [3].

Dr TIM runs on any computer capable of running Java programs that require the Java Virtual Machine (JVM) 1.6. To run Dr TIM, download the Java Archive (JAR) file from the supplementary material and open it. Provided Java is correctly installed, Dr TIM should start up and display the window shown in Fig. 1.

Two sets of parameters need to be adjusted to repeat our simulations, namely the parameters describing the scene, and the parameters describing the camera. This is outlined below. To render the view with new parameters, press the `Render` button on Dr TIM's home screen.

Pressing the `Edit scene` button on Dr TIM's main screen allows editing of the scene. The basic scene we used to illustrate the pinch-transformation window can be created by selecting `Pinch-transformation window` in the `Create new...` drop-down list and by clicking `OK` in the screen that allows editing of the parameters of the new pinch-transformation window. Clicking `OK` again brings up Dr TIM's home screen again, where the modified scene can be rendered by clicking the `Render` button.

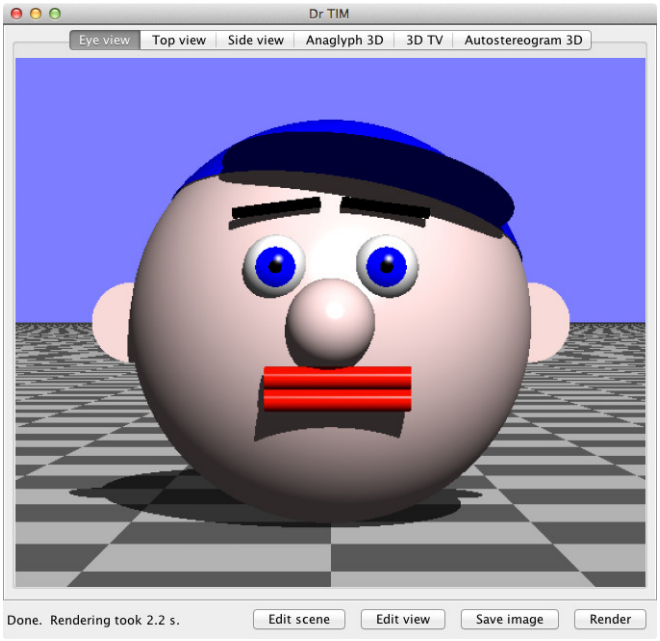

FIG. 1: **Dr TIM's home screen.** The image shows Dr TIM's window, running under Mac OS X, immediately after startup.

The resulting image shows the same scene as that shown in frame **c** in Fig. 2, but it is calculated for a different camera position and direction. These parameters can be changed to those used in the paper by clicking the `Edit view` button and changing the settings to the following values: `Aperture centre` to (1, 0.5, 0), and `View direction` to (-0.2, -0.1, 1). Changing the `Anti-aliasing quality` to `Good` renders the scene at the same resolution that was used in the paper. Clicking on `OK` returns to the home screen again, where the `Render` button needs to be clicked again to show the scene for the new camera parameters.

The remaining frames of Fig. 2 show a modified scene. Additionally, frame **b** uses a different camera position and view direction.

The scene modifications in frame **a** can be achieved as follows. Clicking the `Edit scene` button followed by double-clicking on `Pinch-transformation window` in the list of scene objects brings up the parameters that describe the pinch-transformation window. Clicking the `Convert to collection of scene objects` button makes the individual parts of the window editable. The scene in frame **a** results from clicking on `Windows` in the list of scene objects and then unchecking the `Visible` check box below that list, thereby hiding the refracting surfaces, but not the wall. Clicking `OK` twice followed by `Render` results in frame **a**.

The following further scene modifications result in the scene used in frame **d**. After clicking the `Edit scene` button and double-clicking on `Pinch-transformation window`, make the windows visible again (by clicking on `Windows` and checking the `Visible` checkbox) and then double-click on `Windows` to edit the individual windows. Double-click on `Inner front diagonal window`, select the `Surface` tab, set `eta_u` to 1, and click the `OK` button. Similarly, set the `eta_u` parameter of the surface named `Inner back diagonal window` to 1. Click on `OK` and then `Render` to get the image in frame **d**.

Finally, frame **b** can be reproduced as follows. As before, click on `Edit scene` and then double-click on `Pinch-transformation window`. This time, first make the wall invisible by clicking on `Wall` in the list of scene objects and unchecking the `Visible` checkbox.

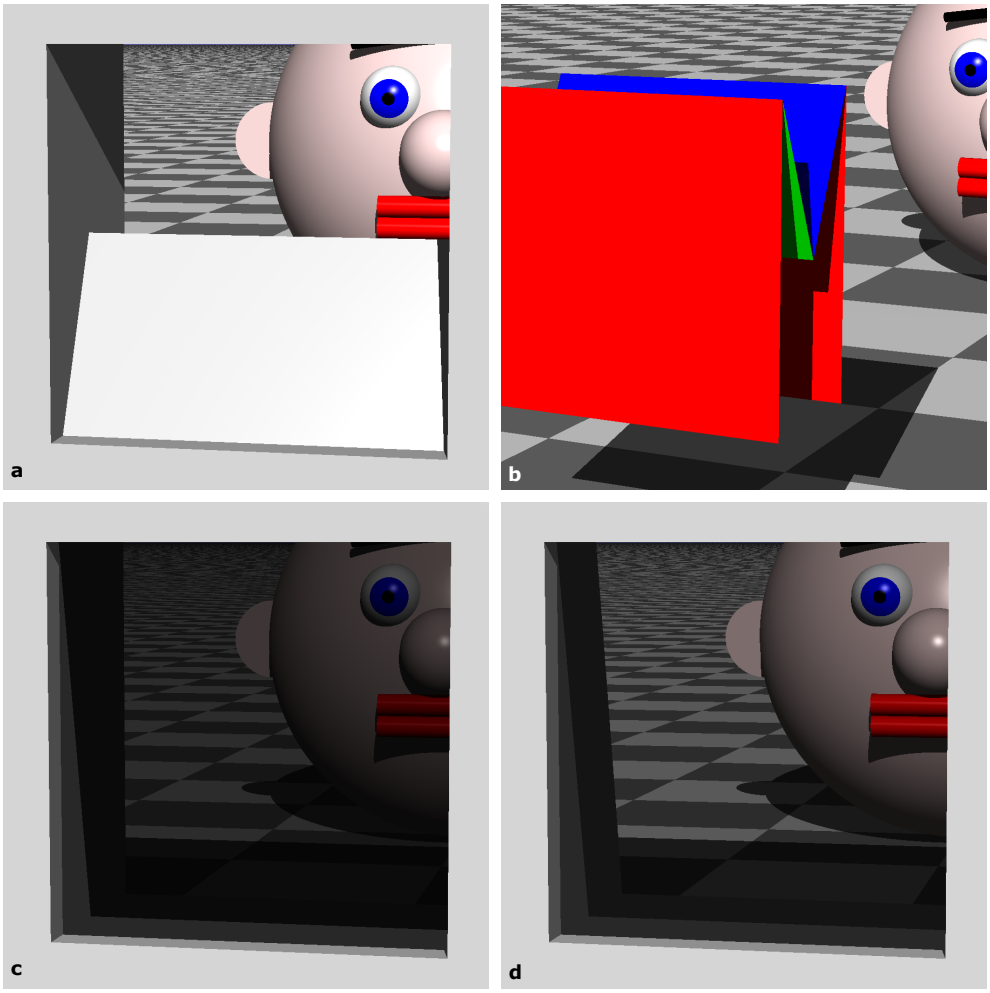

FIG. 2: **Ray-tracing simulation of a pinch-transformation window.** This figure is a reproduction of Fig. 3 in the paper, where details on the interpretation of these images can be found.

Next, double-click on `Windows`. Now make the surfaces coloured. To make the `Front window` a red colour, first double-click on `Front window`, select the `Surface` tab, set the `Surface type` to `Coloured`, and set the colour's RGB components to `R`=1, `G`=0, and `B`=0. Clicking `OK` returns to the list of scene objects in the `Windows` group, from where the other windows can be coloured in a similar manner (the RGB components of the `Inner front diagonal window` should be (0, 1, 0), those of the `Inner back diagonal window` should be (0, 0, 1), and those of the `Back window` should be (1, 0, 0)). Once this is done, click on `OK` until the rendered image is shown. Now click on `Edit view`, set the `Aperture centre` to (2.5, 1, 0) and the `View direction` to (-0.5, -0.2, 1), and click `OK`. Clicking on `Render` now results in the image shown in frame **b**.

[1] D. Lambert, A. C. Hamilton, G. Constable, H. Snehanshu, S. Talati, and J. Courtial, "TIM, a ray-tracing program for METATOY research and its dissemination," Comp. Phys. Commun. **183**, 711–732 (2012).

[2] S. Oxburgh, T. Tyc, and J. Courtial, "Dr TIM: Ray-tracer TIM, with additional specialist capabilities," Comp. Phys. Commun. **185**, 1027–1037 (2014).

[3] D. Lambert, A. C. Hamilton, G. Constable, H. Snehanshu, S. Talati, and J. Courtial, "User guide to TIM, a ray-tracing program for forbidden optics," `http://arxiv.org/abs/1103.5028` (2011).