

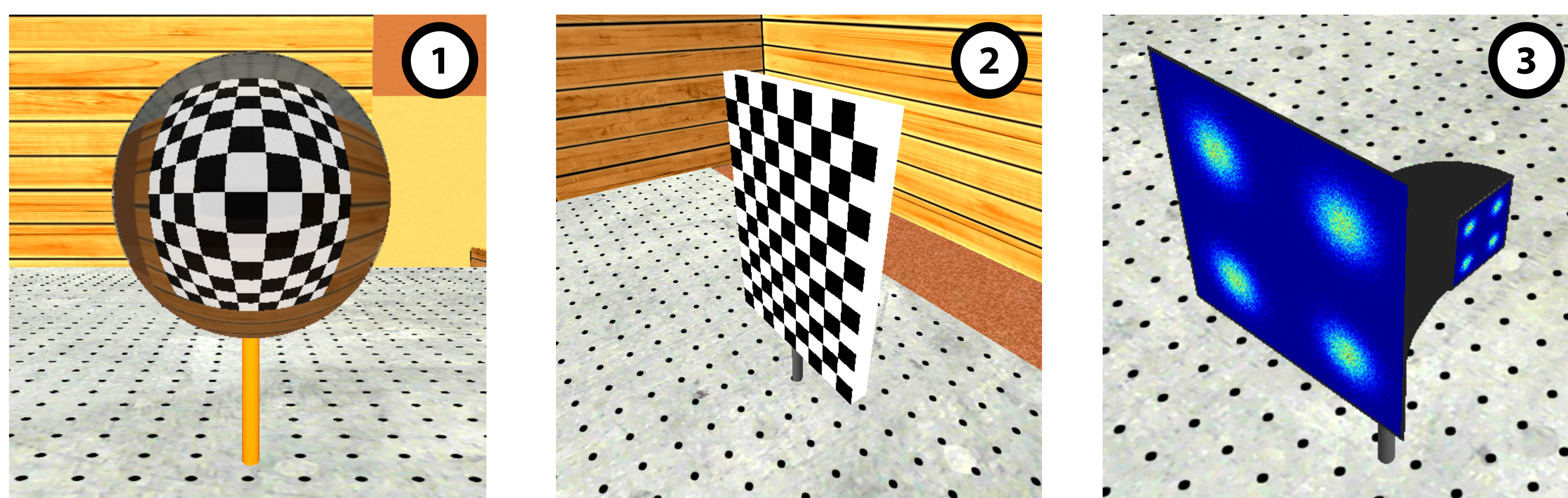
Virtual Optical Bench: A VR learning tool for optical design

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Introduction & Motivation

The design of optical lens assemblies is a difficult process that requires lots of expertise. The teaching of this process today is done on physical optical benches, which are often too expensive for students to purchase. One way of circumventing these costs is to use software to simulate the optical bench. This work presents a virtual optical bench, which leverages realtime ray tracing in combination with VR rendering to create a teaching tool which creates a repeatable, non-hazardous and feature-rich learning environment.

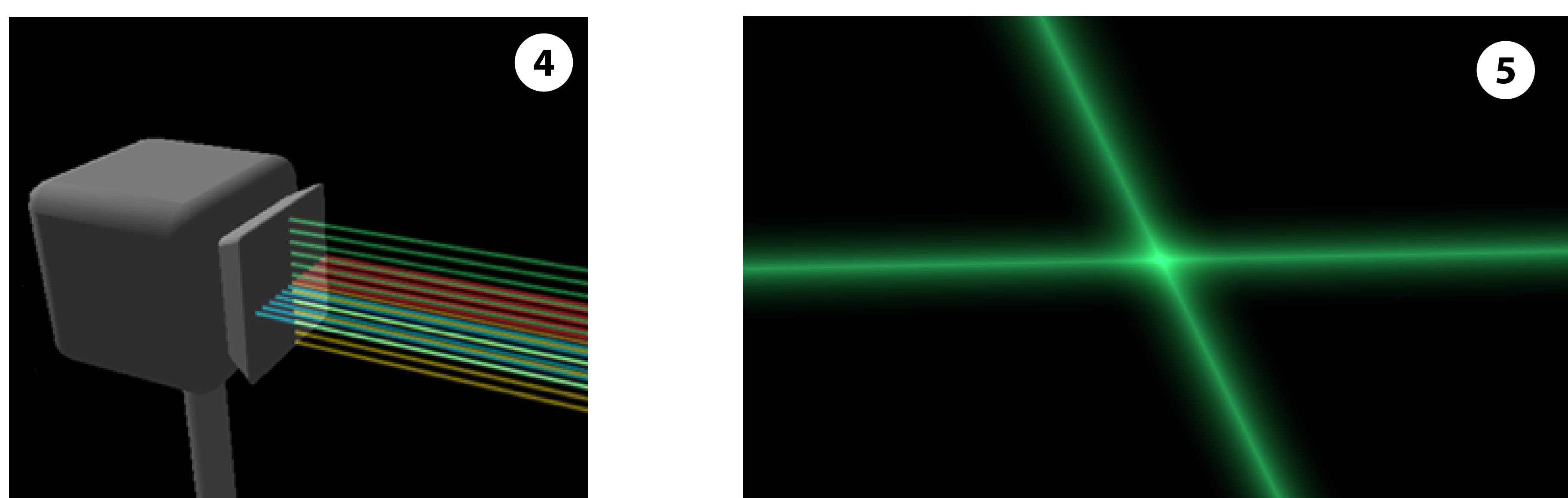
Optical Elements



In the virtual optical bench application three types of optical elements are implemented:

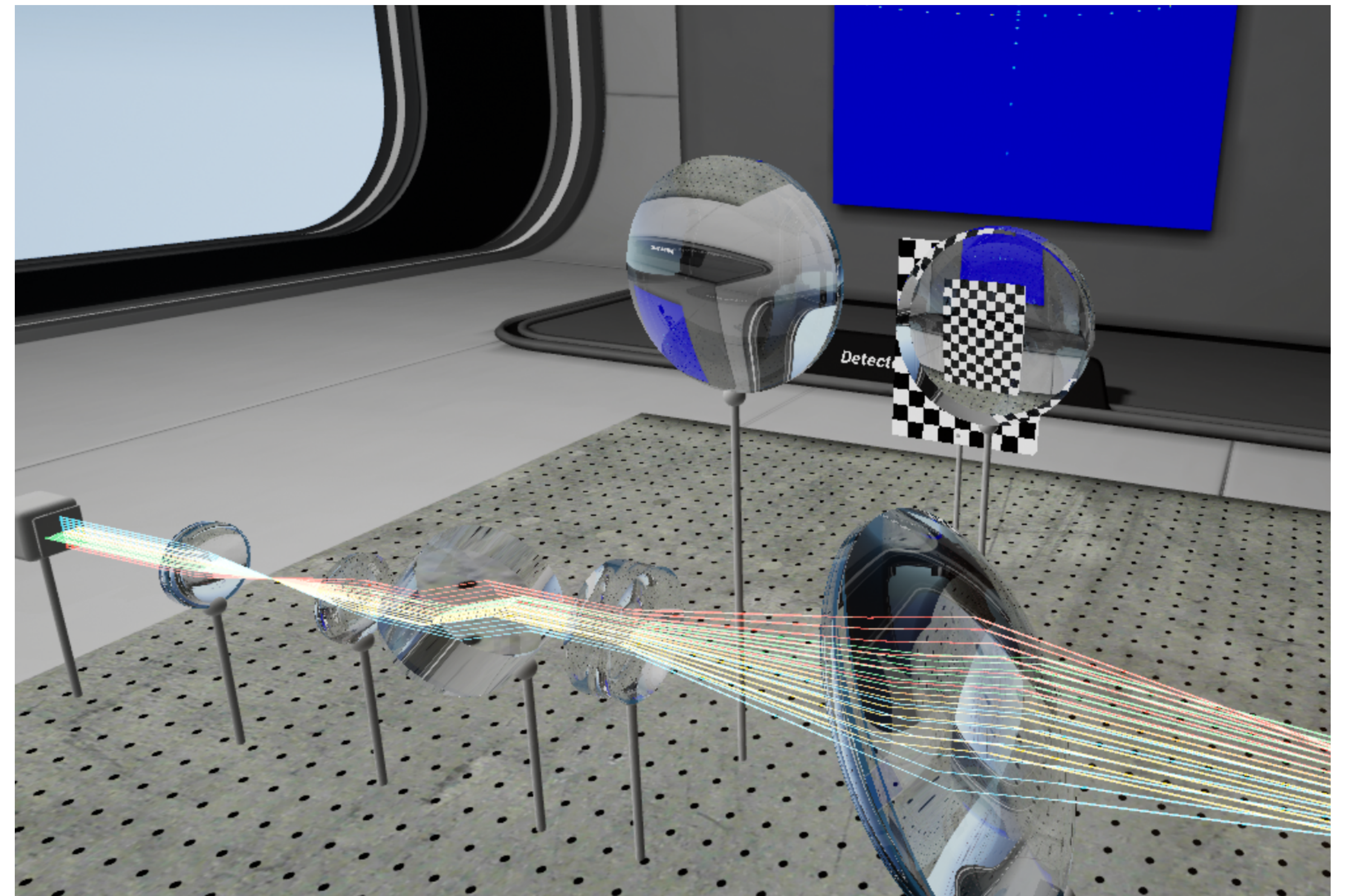
- ① As lens elements, parametric spherical lenses are included as implicit geometry. For a realistic simulation a glass shader based on the Sellmeier and Fresnel-Schlick equations was implemented.
- ② Textured, ray-blocking plane geometry was included for visual distortion analysis as visible in ①.
- ③ A laser detector to detect, record and visualize photon impacts in a heatmap visualization was added.

Laser Simulation



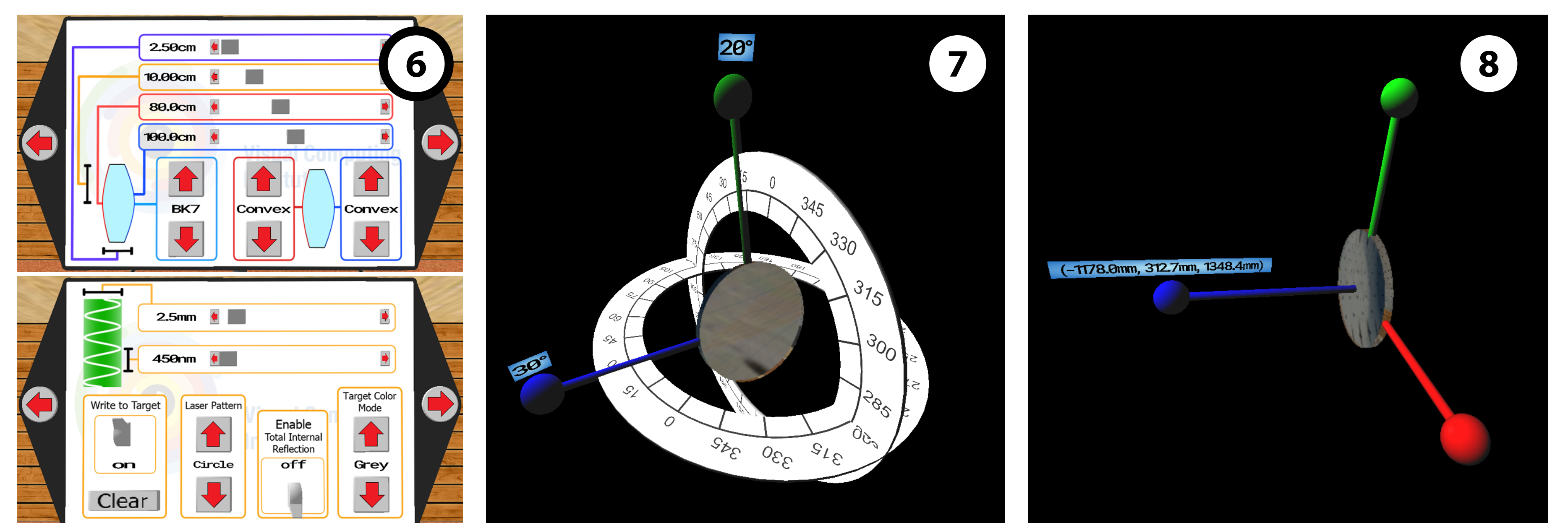
To evaluate lens systems in real setups, often laser emitters with different patterns are used. In this application a laser emitter was implemented as follows:

- ④ The laser emitter emits infinitely thin light rays, which are traced from the laser through all optical elements in the scene. To simulate a variable thickness of the beam without lowering performance, the starting position of the traced light ray is altered according to a normal distribution multiple times per frame. Additionally, the patterns of the laser and its uniform wave length can be adjusted.
- ⑤ The resulting traced laser rays are then rendered as billboard geometry in the engine and are shaded to look like laser rays.



In this screenshot of the application, the optical bench with a set of spherical lenses ① is visible. The laser emitter ④ on the left emits a cross pattern through the stack of lenses, which deform the laser pattern. Additionally, the optical effect of one lens on the top right is visualized with an optical target plane ②. In the background, the resulting beam pattern is captured via the detector ③ and visualized on the wall.

Interaction



To interact with the optical elements and laser simulation a simple menu metaphor and two gizmos were implemented:

- ⑥ With the virtual tablet as a central control hub, the user can change the parameters of all components or create new components.
- ⑦ To increase the angular precision for turning the lenses with typical HMD controllers, the rotation gizmo features extending arms with angle gauges, which therefore offer infinite angular precision.
- ⑧ The implemented translation gizmo features extending arms as well to keep the connection between the user and the object, while scaling the input by a factor of 10.

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