Advanced Gaze Visualizations for Three-dimensional Virtual Environments

Sophie Stellmach, Lennart Nacke and Raimund Dachselt | Otto von Guericke University of Magdeburg, Germany

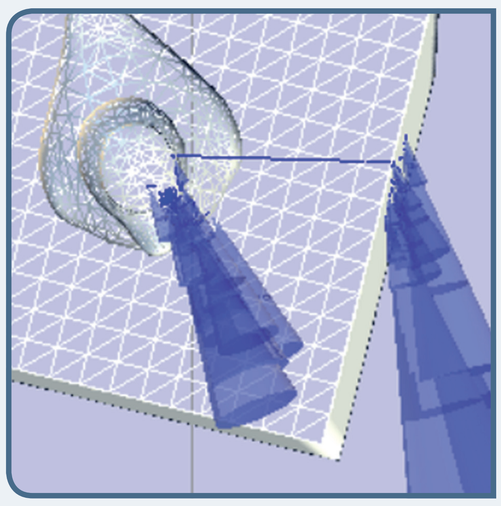
Motivation & Summary

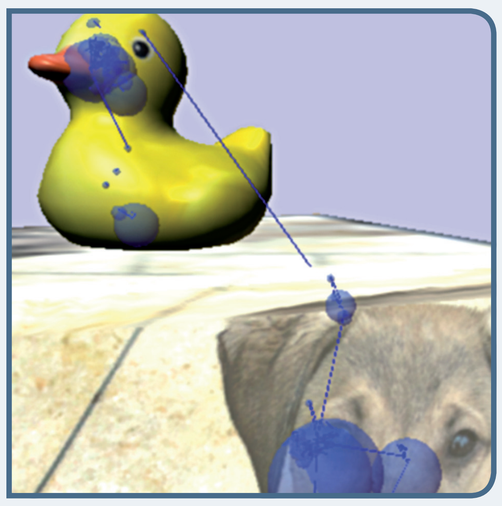
Gaze visualizations represent an effective way for gaining fast insights into eye tracking data. Current approaches do not adequately support eye tracking studies for three-dimensional (3D) virtual environments.

We propose a set of advanced gaze visualization techniques for supporting gaze behavior analysis in such environments. Similar to commonly used gaze visualizations for two-dimensional stimuli (e.g., images and websites), we contribute advanced **3D scan paths** with associated camera paths. In addition, we introduce **3D attentional maps** and a **models of interest timeline** depicting viewed models, which can be used for displaying scan paths in a selected time segment.

A prototype toolkit SVEETER has been developed which combines an implementation of our proposed techniques. Their potential for facilitating eye tracking studies in virtual environments was supported by a user study among eye tracking and visualization experts.

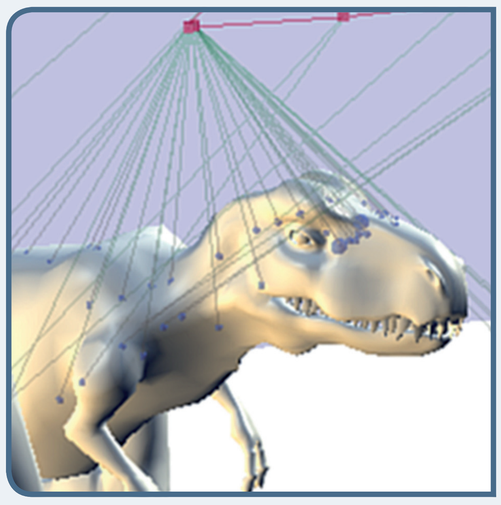
3D Scan and Camera Paths





3D Scan Paths

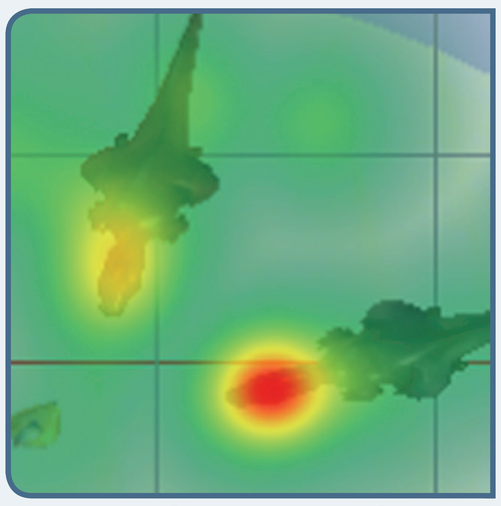
Depiction of fixations and saccades within a virtual environment. Two alternative fixation representations (cones and spheres) have been implemented.



3D Camera Paths

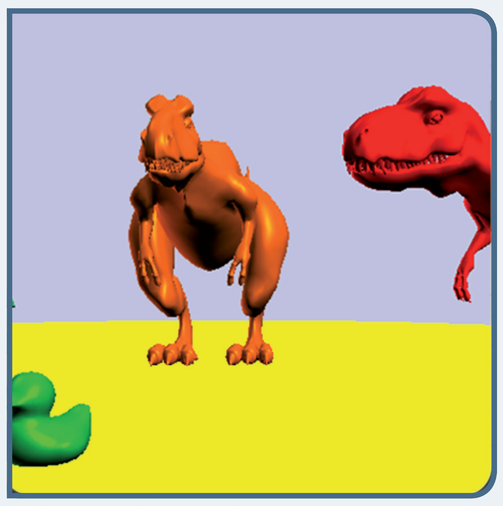
For exploring a 3D scene it is essential that users can freely move within the environment. For this purpose, viewpoints and viewing directions have to be visualized with reference to the 3D scan paths.

3D Attentional Maps



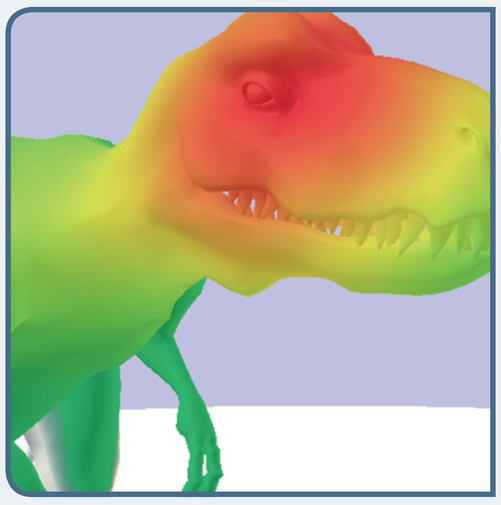
Projected Attentional Maps

... are two-dimensional representations of 3D gaze distributions for selected arbitrary views.



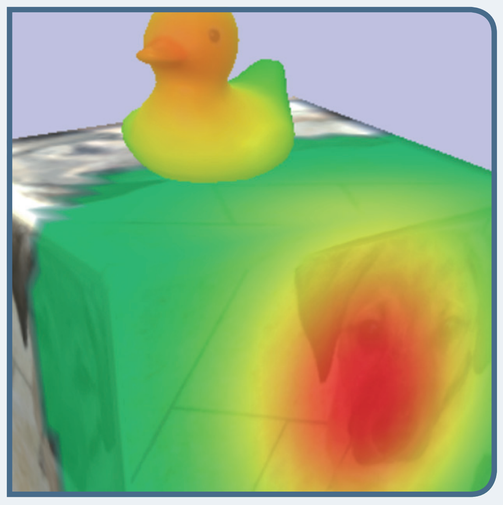
Object-based Heatmaps

... have a color mapped to the surface of each model based on its received visual attention.

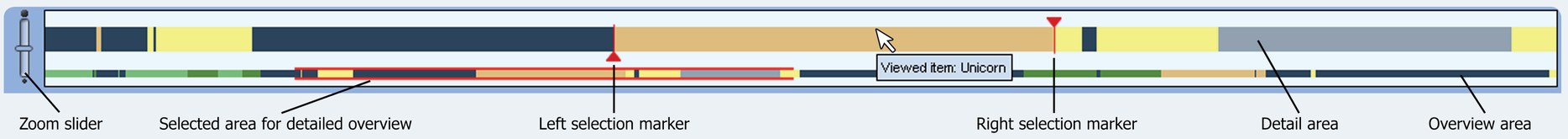


Surface-based Attentional Maps

... display aggregated fixation data as heatmaps directly on a model's surface using a vertex-based mapping.

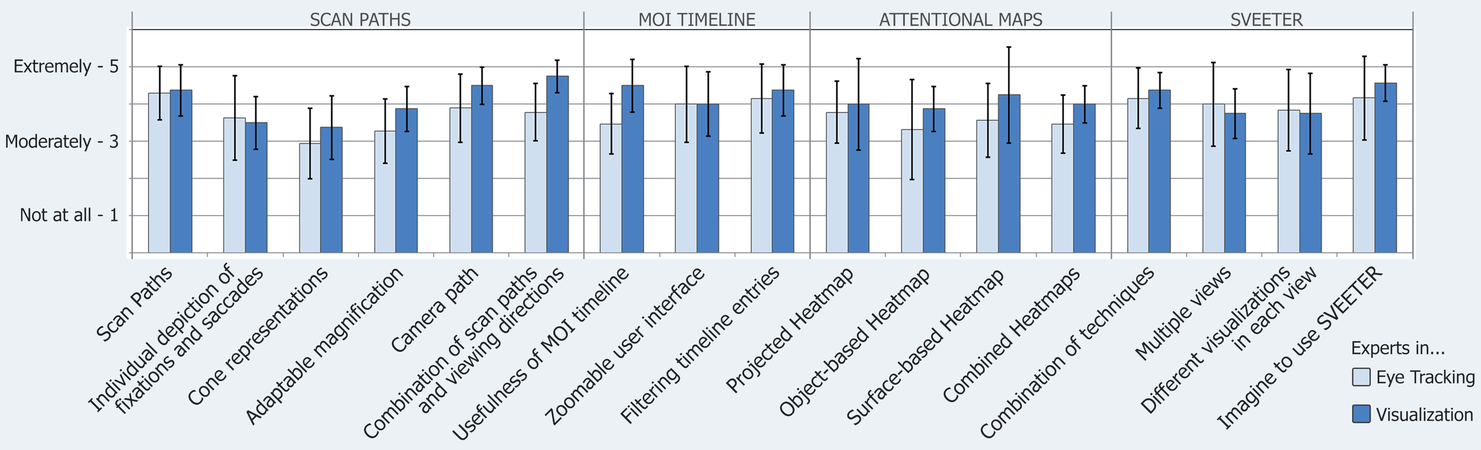


Models of Interest Timeline



The **MOI timeline** gives an overview about a user's gaze distribution based on viewed models. Each model is labeled with a specific color, which can be manually adapted.

Formative Study



A formative user study with 20 eye tracking and 8 visualization experts has been conducted to assess the usefulness of the presented techniques.

Measures. The usefulness of the gaze visualization techniques was investigated in an online survey. Each technique was briefly described with screenshots. Respondents were asked to rate their agreement to statements such as "Cone visualizations are useful for representing fixations in virtual environments." The qualitative part of the survey collected comments about usefulness, improvements, and possible applications of the techniques.

Sophie Stellmach, Lennart Nacke and Raimund Dachselt
{stellmach, lennart.nacke, dachselt}@acm.org
User Interface & Software Engineering Group (UISE)

OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG
FAKULTÄT FÜR INFORMATIK