06221 Abstracts Collection
Computational Aesthetics in Graphics, Visualization and Imaging
— Dagstuhl Seminar —

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Abstract. From 28.05.06 to 02.06.06, the Dagstuhl Seminar 06221 "Computational Aesthetics in Graphics, Visualization and Imaging" was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed. Abstracts of the presentations given during the seminar as well as abstracts of seminar results and ideas are put together in this paper. The first section describes the seminar topics and goals in general. Links to extended abstracts or full papers are provided, if available.

Keywords. Lighting Design and Image Relighting, Non-Photorealistic Rendering, Technical Illustration, Medical Illustration, Computational Color Harmony, Color Dynamics , Color Environmental Design, Color Preferences / Effects and Roles of Colors

06221 Dagstuhl Report – Computational Aesthetics in Graphics,Visualization and Imaging

The Dagstuhl-Seminar on Computational Aesthetics in Graphics, Visualization and Imaging took place from 28 May until 2 June, 2006, with 54 registered participants and some visiting PhD students from Germany. The high interest in the topics dealt at the seminar resulted in a tight scheduling of presentations and panel discussions.

Keywords: Lighting Design and Image Relighting, Non-Photorealistic Rendering, Technical Illustration, Medical Illustration, Computational Color Harmony, Color Dynamics , Color Environmental Design, Color Preferences / Effects and Roles of Colors

Joint work of: Gooch, Bruce; Neumann, László; Purgathofer, Werner; Sbert, Mateu

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2007/874

Lerning from the artists: spatial enhancement in CG images

We present a simple and efficient method to enhance the perceptual quality of images that contain depth information. Similar to an unsharp mask, the difference between the original depth buffer content and a low-pass filtered copy is utilized to determine information about spatially important areas in a scene. Based on this information we locally enhance the contrast, color, and other parameters of the image. Our technique aims at improving the perception of complex scenes by introducing additional depth cues. The idea is motivated by artwork and neurology, and can be applied to images of any kind, ranging from complex landscape data and technical artifacts, to volume rendering, photograph, and video with depth information.

Keywords: Perception, depth buffer

Stylized Reality

Dirk Bartz (Universität Tübingen, D)

When combining Reality and Virtuality into an Augmented or Mixed Reality System, the rendering of the embedded virtual objects clearly exposes them as virtual. This is due much coarser material properties and due to the inconsistent lighting, when compared with the Reality.

We defined a novel approach that aims at diminishing these differences, Stylized Reality. Here, we apply a series of image and object space filters to provide a stylization (non-photorealistic rendering) of the representation. Due to this stylization, it is much harder to differentiate between virtual and real objects in the combined display.

In my talk, I will demonstrate different approaches for this stylization and I will present results from psychophysical experiments that show its effectiveness.

Keywords: Virtual Reality, Augmented/Mixed Reality, illustrative rendering, stylized rendering, NPR

Joint work of: Bartz, Dirk; Fischer, Jan; Salah, Zein; Cunningham, Douglas; Wallraven, Christian

Evaluation of Tone Mapping Operators Using Image Attributes

Martin Cadik (Czech Technical University, CZ)

The problem of reproducing high dynamic range images on devices with restricted dynamic range has recently gained a lot of interest.

There exist various approaches to this issue, which span several research areas including computer graphics, image processing, color science, physiology, neurology, psychology, etc. These approaches assume a thorough knowledge of both the objective and subjective attributes of an image. We present an overview of image quality attributes of different tone mapping methods. Furthermore, we propose a scheme of relationships between these attributes, leading to the definition of an overall image quality measure. We present results of subjective psychophysical tests and experiments that we have performed to prove the proposed relationship scheme. Our effort sets the stage for well-founded quality comparisons between tone mapping operators. By providing good definitions of the different attributes, user-driven or fully automatic comparisons are made possible at all.

Keywords: Tone mapping, HDR, TMO, evaluation, human perception

Joint work of: Cadik, Martin; Wimmer, M.; Neumann, L.; Artusi, A.

Full Paper:
http://www.cgg.cvut.cz/∼cadikm/tmo/

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Keywords: Tone mapping, HDRI, image quality evaluation

Joint work of: Cadik, Martin; Neumann, László

Facial expressions, stylization, and psychophysical evaluation

Douglas Cunningham (Universität Tübingen, D)

Our ability to convey complex meaning and emotion by the clever arrangement of symbols and signs is one of the most celebrated aspects of our human heritage.

Aesthetics is often characterized as "sign" – more specifically as the interaction between symbol and observer within a social context. Perception, then, can be characterized as a "mutuality", or the interaction between the observer and an event or object, within an environmental context. In this talk, we will show (with the help of a variety of visual illusion) that our perceptual experience of the world is fundamentally different then the physical descriptions of the elements of the world. We will then focus on the role of stylization, as it is used by visual artists, to selectively emphasize information in a way that increases its saliency for human perception. We will then quickly examine several perceptual studies that examine the different ways of evaluating the impact of stylization of facial animations on communication.

Keywords: Perception, animation, stylization, facial expression, evaluation

Joint work of: Cunningham, Douglas W.; Wallraven, Christian; Bartz, Dirk; Fischer, Jan; Bülthoff, Heinrich H.; Straßer, Wolfgang

Illustrative Visualization: Goals and Questions

David S. Ebert (Purdue University, USA)

We believe that the goal of visualization is to effectively convey information to the user and that you must start with understanding the purpose/question for the visualization. Then, you determine the relevant data and level of representation that is most appropriate and map this to an effective visual abstraction. This visual abstraction should be engaging, easily comprehended and visually appealing to the user and adapted to their learning preferences, perceptual preferences, experience level, task, and the device being used.

Keywords: Illustration, visualization

Joint work of: Ebert, David S.; Sousa, Mario Costa; Stredney, Don; Svakhine, Nikolai

A Unified Information-Theoretic Framework for Viewpoint Selection

Miquel Feixas (University of Girona, E)

Viewpoint selection is an emerging area in computer graphics with applications in fields such as scene exploration, volume visualization, image-based modeling, and molecular visualization. In this talk, we present a unified framework for viewpoint selection and mesh saliency based on the definition of an information channel between a set of viewpoints and the set of polygons of an object.

The mutual information of this channel is shown to be a powerful tool to deal with viewpoint selection, viewpoint clustering and scene exploration. Although we use a sphere of viewpoints around an object, our framework is also valid for any set of viewpoints in a closed scene.

Keywords: Viewpoint selection, scene exploration, information theory

Joint work of: Feixas, Miquel; Sbert, Mateu; González, Francisco; Rigau, Jaume

The Beauty of Developable Surfaces

Georg Glaeser (Universität für Angewandte Kunst - Wien, A)

Developable surfaces (cylinders, cones and torses) are of special interest in differential geometry, since they have vanishing main curvature and thus can be rectified into the plane. In practice, they are of value in avantgarde architecture, where smooth surfaces are requested and construction prices should not exceed certain limits. Such surfaces can be generated by moving planes or as tangent surfaces of space curves. Thus, they are dual to space curves and easy to handle. We developed an interactive software that allows to define and adapt developable surfaces interactively and in real time, avoiding self-intersections. Several surfaces put together create new structures that are completely developable. All necessary algorithms, e.g., an extended gamma-buffer, are extremely efficient, using the special properties of torses.

Keywords: Developable surface, torse, gamma-buffer, smooth surfaces

Joint work of: Glaeser, Georg; Gruber, Franz

Visualizing Pentimenti: the Hidden History in a Painting

Amy Gooch (NW University - Evanston, USA)

Art conservators often explore X-ray images of paintings to help find *pentimenti*, the artist's revisions hidden beneath the painting's visible first surfaces. X-ray interpretation is difficult because framing, canvas damage, and noise clutter the image; because X-rays superimpose features from all paint layers, and because image intensity depends on both the paint layer thickness and each pigment's opacity. I present a robust user-guided method to suppress clutter, find visually significant differences between X-ray images and color photographs, and visualize them together. These new techniques rely on region-based statistics in order to create a mapping of the regions that do and do not correspond in the visible light image and X-ray image of a painting. These tools, developed for ongoing conservation projects at the Art Institute of Chicago, allow domain experts as well as museum visitors to explore the artist's creative decisions that led to a masterpiece.

Keywords: Visualization, art

Evolutionary Computation and Image Re-Coloring

Gary R. Greenfield (University of Richmond, USA)

We consider the role evolutionary computation has to play in computational aesthetics by examining the problem of image re-colorization.

Our context is re-colorization based on color look-up tables. We propose a framework for evolving such tables and address the key issue of how to evaulate the re-coloring results.

We show some results obtained using evolutionary multiobjective optimization. This leads to a discussion culminating in ideas and suggestions for future work.

Keywords: Image re-coloring, evolutionary computation, color look-up table

Mapped Pictures: Aesthetic Image Annotations

Knut Hartmann (Universität Magdeburg, D)

Edward Tufte introduced the term "Mapped Pictures" to describe a class of illustrations which smoothly integrates explanations directly into visualization. He characterize them like this:

- Explanatory [...] images should nearly alway be mapped, contextualized [...]
- Mapped pictures combine representational images with scales, diagrams, overlays, numbers, words, or images
- An explanatory image is an explanatory image because it is a mapped image
- Sensible mapped pictures nearly always outperform purely pictorial representations for presenting, explaining, and documenting evidence

Quote: Edward Tufte, Beautiful Evidence, 2006 taken from E. R. Tufte and others. Ask E.T.: Mapped Pictures: Image Annotation.
http://www.edwardtufte.com/bboard/

Tufte also distinguished between primary, secondary, and structural layout elements. We present several prototypes, which automatically integrates secondary and structural elements into interactive environments. Their layout has to be aesthetic in order to support functional requirements such as readability and unambiguity.

Keywords: Label Layout, View Management

Joint work of: Hartmann, Knut; Götzelmann, Timo ; Kamran, Ali; Strothotte, Thomas

An Approach to the Perceptual Optimization of Visualizations

Donald H. House (Texas A&M University, USA)

This talk proposes a new experimental framework within which evidence regarding the perceptual characteristics of a visualization method can be collected, and describes how this evidence can be explored to discover principles and insights to guide the design of perceptually near-optimal visualizations. We make the case that each of the current approaches for evaluating visualizations is limited in what it can tell us about optimal tuning and visual design. We go on to argue that our new human-in-the-loop approach is better suited to optimizing the kinds of complex visual displays that are commonly

created in visualization. Our method searches the parameter space of a visualization method, guided by subject ratings, generating large databases of rated visualization solutions. Data mining is then used to extract results from the database, ranging from highly specific exemplar visualizations for a particular data set, to more broadly applicable guidelines for visualization design. We illustrate our approach using recent studies of optimal texturing for layered surfaces. We show that a genetic algorithm is a valuable way of guiding the human-in-the-loop parameter space search. We also demonstrate several useful data mining methods including clustering, ANOVA, linear discriminant analysis, neural networks, decision trees, statistical comparisons of functions of parameters, and parallel coordinates.

Keywords: Visualization, layered surfaces, perceptual optimization, human-in-the-loop, data mining

Color Aesthetics in Visualization and Natural Images

Victoria Interrante (University of Minnesota, USA)

Why is it that, when representing data via color, the use of some color palettes yields results that are so much more visually pleasing than others? Is there a relationship between aesthetic color usage and the statistics of color appearance in natural images? In this presentation, we describe the preliminary steps that we have taken in beginning to explore this question. Working in the perceptually linear L*a*b* color space, we compare some simple statistics of the color population in a small set of images randomly chosen from the proceedings of the 2005 IEEE Information Visualization conference to the statistics of an equivalent number of images randomly chosen from the McGill calibrated colour image database. We also compare observers' aesthetic ratings of 'scrambled' versions of these same images, in which the structural information has been removed and only the color population information remains. We find that there are some characteristic differences in the statistics of the color populations between the two sets of images, that the color populations from the natural image set are generally, but not uniformly, rated as more aesthetic that the color populations from the visualization image set, and that the statistics of the color populations of the most highly rated images from the visualization image set were more closely matched to the statistics of the color populations in the natural image set than to the statistics of the color populations in the visualization image set, as a whole.

Keywords: Color aesthetics, statistics of natural images

Joint work of: Interrante, Victoria; Saunders, P. Coleman

Aesthetics of Hand-Drawn and Computer-Generated Illustrations

Tobias Isenberg (University of Calgary, CA)

We recently designed and conducted a study in which 24 participants compared computer-generated with hand-drawn pen-end-ink illustrations.

Based on our findings, my talk will discuss two aspects: (1) the specific differences between computer-generated and hand-drawn illustrations that were brought up by the participants and (2) what did or did not appeal to the participants in either type of illustration. This talk forms an extension to my talk at NPAR that will discuss more general study setup and results.

Keywords: Non-photorealistic rendering (NPR), evaluation of NPR and traditional scientific illustration, observational study, pen-and-ink illustration.

Joint work of: Isenberg, Tobias; Neumann, Petra; Carpendale, Sheelagh; Costa Sousa, Mario; Jorge, Joaquim A.

Flocking Strokes

Pauline Jepp (University of Calgary, CA)

Particle systems provide the basis for interesting alternative methods of rendering implicit models and creating effective visualizations of an iso-surface. Surface features, however, can be difficult to see with traditional styles of particle renderings. Therefore, particle systems have been used to position strokes rather than draw oriented discs or other more traditional particle shapes. Detection of surface features still remains a problem related to the distribution of the particles. In this research a new technique to sample and position strokes for pen-and-ink style rendering of implicit surfaces is presented. Steering and flocking behaviours are employed to direct particles to sample and render in the same pass.

Keywords: Computer Graphics, Non-Photorealistic Rendering

Joint work of: Jepp, Pauline; Wyvill, Brian; Sousa, Mario Costa

A note on optimization

Craig S. Kaplan (University of Waterloo, CA)

I present some recent work on generating halftoned images via the Traveling Salesman Problem, and use it to motivate questions related to computers and aesthetics. In particular, I ask whether aesthetic value exists for computational properties such as optimization, imperfection, and randomness. I also ask whether the value of these tools can be quantified.

Digital Face Beautification

Dani Lischinski (The Hebrew University of Jerusalem, IL)

We present a novel method for digital face beautification: given a frontal photograph of a face (a portrait), our method automatically increases the predicted attractiveness rating of the face.

The main challenge is to achieve this goal while introducing only minute, subtle modifications to the original image, such that the resulting "beautified" face maintains a strong, unmistakable similarity to the original. The effectiveness of the proposed method was experimentally validated by a group of test subjects who consistently rated the modified faces as more attractive than the original ones.

Keywords: Facial attractiveness, image warping, machine learning

Joint work of: Leyvand, Tommer; Cohen-Or, Daniel; Dror, Gideon; Lischinski, Dani

What Will Make Us Aesthetics Experts?

Gary Meyer (University of Minnesota, USA)

From the earliest days of computer graphics, aesthetics has played a role in the synthesis of realistic images. As our rendering algorithms have become more sophisticated and our hardware has increased in power, an even greater understanding and appreciation for aesthetics is required to take advantage of these capabilities and to control all of the variables that can be manipulated. While aesthetics plays an increasingly important role in traditional computer graphics, the formal training that our students receive is still limited to the usual technical subjects in the computer science and engineering disciplines. The study of computational aesthetics will put aesthetics at the bull's eye of our research targets and will make it even more important that our students learn something about material that is usually covered in the artistic and design fields.

In my talk I will argue that technical students who create aesthetic objects must learn some basic principles of art and design, just as artists and architects are now encouraged (and even forced) to gain a basic understanding of computers and software applications. I will discuss the role that aesthetics plays in my color appearance research, I will talk about the frustrations that I have endured because of my students (and my own) aesthetic ignorance, and I will describe a recent color course that brought together design and computer science students to learn from each other and to collaborate on interdisciplinary projects. The goal of my talk is to stimulate a discussion regarding the importance of aesthetic training for science and engineering students and to learn what other participants are doing to address this problem in their own research areas.

Beyond Tone Mapping: Enhanced Depiction of Tone Mapped HDR Images

Karol Myszkowski (MPI für Informatik - Saarbrücken, D)

High Dynamic Range (HDR) images capture the full range of luminance present in real world scenes, and unlike Low Dynamic Range (LDR) images, can simultaneously contain detailed information in the deepest of shadows and the brightest of light sources. For display or aesthetic purposes, it is often necessary to perform tone mapping, which creates LDR depictions of HDR images at the cost of contrast information loss. The

purpose of this work is two-fold: to analyze a displayed LDR image against its original HDR counterpart in terms of perceived contrast distortion, and to enhance the LDR depiction with perceptually driven colour adjustments to restore the original HDR contrast information. For analysis, we present a novel algorithm for the characterization of tone mapping distortion in terms of observed loss of global contrast, and loss of contour and texture details. We classify existing tone mapping operators accordingly. We measure both distortions with perceptual metrics that enable the automatic and meaningful enhancement of LDR depictions. For image enhancement, we identify artistic and photographic colour techniques from which we derive adjustments that create contrast with colour. The enhanced LDR image is an improved depiction of the original HDR image with restored contrast information.

Keywords: Tone mapping, chroma manipulation, contrast enhacement, countershading

Joint work of: Smith, Kaleigh; Krawczyk, Grzegorz; Myszkowski, Karol; Seidel, Hans-Peter

Full Paper:
http://www.mpi-inf.mpg.de/resources/hdr/enhancedHDR/

See also: full version to be published at Eurographics 2006

Sub-Resolution Detail Generation for Illustrative Rendering Using Constrained Texture Synthesis

Klaus Müller (SUNY at Stony Brook, USA)

A common deficiency of discretized datasets is that detail beyond the resolution of the dataset has been irrecoverably lost. This lack of detail becomes immediately apparent once one attempts to zoom into the dataset and only recovers blur. Here, we describe a method which generates the missing detail from any available and plausible high-resolution data, using texture synthesis. Since the detail generation process is guided by the underlying image or volume data and is designed to fill in plausible detail in accordance with the coarse structure and properties of the zoomed-in neighborhood, we refer to our method as constrained texture synthesis. Regular zooms become "semantic zooms", where each level of detail stems from a data source attuned to that resolution. We demonstrate our approach by a medical application - the visualization of a human liver - but its principles readily apply to any scenario, as long as data at all resolutions are available. Our technique opens new opportunities for illustrative rendering as it allows multi-modal data to be plausibly fused for a holistic viewing experience of the object. Our application acts like a (virtual) microscope with an unlimited and seamless magnification range, provided detail samples at all semantic resolutions are available.

Keywords: Ilustrative rendering, semantic zoom, texture synthesis, super-resolution, data fusion

Full Paper:
http://www.cs.sunysb.edu/∼lujin/paper/vis04/

See also: L. Wang and K. Mueller, "Enhancing volumetric datasets with sub-resolution detail using texture synthesis," IEEE Visualization '04, pp. 75-82, Austin, October 2004.

High Dynamic Range Imaging using Multi-CLAHE methods

Attila Neumann (TU Wien, A)

A Histogram Equalization based HDRI image processing method has been presented. The method can be used in photography as well as medical visualization purposes. The method relies on 3 basically new ideas, as follows. Maxrgb principle is used for obtaining single values from the RGB input, which is a new approach, and it can be applied for any Tone Mapping operator. The contrast limited histogram equalization has been used hitherto only for eliminating too much increase of contrast. We introduced a lower and upper limitation of the histogram which prevents from too much decrease of contrast as well. Contrast Limited Adopted Histogram Equalization applies this method on areas of the image with limited size, then smoothing such overlapping areas. A series of CLAHE steps with decreasing size of area forms the Multi-step CLAHE being the final result of the presentation. Many parameters can be set for separate purposes as well as classes of images in order to get the most appealing LDR output, or meeting other specific demands.

Keywords: Image processing, Tone mapping, local tone mapping operator, histogram equalization, HDRI

Joint work of: Neumann, Attila; Neumann László

Gradient Importance based High Dynamic Range Imaging

László Neumann (University of Girona, E)

We introduce a new gradient based High Dynamic Range Imaging approach and solution technique. Differently from earlier gradient based techniques we don't compress or modify the original gradient field. It remains 'consistent' or 'conservative'.

Instead the original gradient field we introduce and manipulate the 'Gradient Importance Field' containing weight factors in the objective function, which is minimized.

Another important novelty in the new method is to apply lower-upper limitations of luminance, which ensures the prescribed contrast for arbitrary display devices.

Keywords: HDRI, Gradient Domain Imaging, Gradient Importance Field

Joint work of: Neumann, László; Cadik, Martin

Faithful Color with Flash

Georg Petschnigg (Microsoft Research, USA)

Photography with flash in indoor and outdoor environments poses a challenge to white balancing algorithms, as the scene is illuminated by two or more different light sources. For example, correcting for the joint effects of the blue tone of flash light and the red tone of indoor light bulbs in a single image is an under constrained problem, with previous approaches causing unnatural looking color casts. Our technique makes use of an image pair, one taken with flash, the other without and shows how to correct for ambient and flash illumination separately. This results in faithful looking colors. Next we demonstrate our result in two applications: The first is continuous extrapolation of flash intensity from the ambient to the flash image and beyond. The other is a bronzing flash, which tones areas exposed (such as a model's skin) by the flash golden.
Keywords: Computational Digital Photography, Color, Whitebalancing

A Unified Information-Theoretic Framework for Viewpoint Selection: Applications to Mesh Visibility, Saliency and Simplification

Mateu Sbert (University of Girona, E)

Mesh saliency and mesh visibility are analyzed using the mutual information of the reversed channel obtained by interchanging the input (viewpoints) and the output (polygons of the object). Also, the change in mutual information from the viewpoint is used as a measure for the quality of a simplification of the mesh. Our experiments show the robustness of the several general applications thanks to the good behaviour of the proposed measures.

Keywords: Viewpoint selection, mesh saliency, mesh visibility, mesh

Joint work of: Sbert, Mateu; Feixas, Miquel; González, Francisco; García, Ismael; Castelló, Pascual Chover Miguel

Crest Lines and Viewpoint Selection

Georgios Stylianou (Cyprus College University, CY)

Crest lines are mathematically defined surface shape features. They are computed using only local operators and they capture global surface information. They are versatile as they capture ridges and valleys from terrain surfaces and sulci and gyri from brain (cortex) surfaces. We presend a historical overview of crest lines and sample of various applications used for including rigid and non-rigid registration, decimation, parametrization. Finally, we show some encouraging preliminary experimental results on viewpoint selection using crest lines.

Keywords: Crest lines, viewpoint selection

Silhouette-aware saliency

Pere-Pau Vazquez (TU of Catalonia - Barcelona, E)

In this work we present a set of silhouette-based measures for the analysis of silhouette importance. We show that the presented silhouette analysis may be used for fast viewpoint selection. We also present hardware-accelerated algorithms to compute these measures. Furthermore, we explore the use of those measures for the perception-based generation of approximated representations suitable for normal-mapped rendering. Our saliency-guided simplification combines the mesh saliency concept with an entropy-based measure of the outer silhouette saliency.

Keywords: Mesh saliency, silhouette, entropy

Joint work of: Vazquez, Pere-Pau; Andújar, Carlos

Importance-Driven Focus of Attention

Ivan Viola (TU Wien, A)

We introduce a concept for automatic focusing on features within a volumetric data set. The user selects a focus, i.e., object of interest, from a set of pre-defined features. Our system automatically determines the most expressive view on this feature. An optimal viewpoint is estimated by a novel information-theoretic framework which is based on mutual information measure. Viewpoints change smoothly by switching the focus from one feature to another one. This mechanism is controlled by changes in the importance distribution among features in the volume. The highest importance is assigned to the feature in focus. Apart from viewpoint selection, the focusing mechanism also steers visual emphasis by assigning a visually more prominent representation. To allow a clear view on features that are normally occluded by other parts of the volume, the focusing also incorporates cut-away views.

Aesthetics and Relativity

Daniel Weiskopf (Simon Fraser University, CA)

Special and general relativity are based on 4D spacetime. One way of visualizing spacetime is to trace light rays in order to imitate images taken by a virtual camera. In the particular case of special relativity, light is subject to the relativistic aberration of light. Aberration essentially leads to non-linear image deformations, similar to those generated by some fish-eye lenses. In the case of general relativity, light rays follow possibly curved geodesics, which can result in gravitational lensing. Therefore, both special and general relativity can be considered as a example of a physical basis for non-linear image deformations. This talk discusses what makes relativistic visualizations compelling (for lay-persons and physicists) - for example, symmetry, image invariance, recognition of known objects, etc. It also addresses possibilities of using a general camera model for aesthetic visualizations.

Keywords: Visualization, special relativity, general relativity, gravitational lensing, non-linear deformation