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Diplomarbeitspräsentation

Decoupling Object Manipulation from Rendering in a Thin Client Visualization System

Masterstudium:
Visual Computing

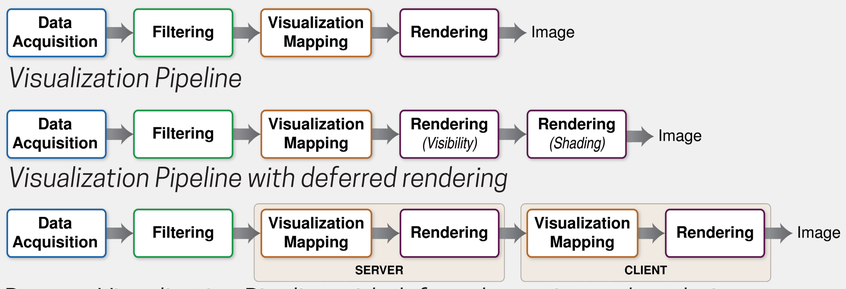
Anna Frühstück

Technische Universität Wien
Institut für Computergraphik und Algorithmen
Arbeitsbereich Computergraphik
Betreuer: Ao.Univ.-Prof. Dipl.-Ing. Dr. M. Eduard Gröller

MOTIVATION Often, users of visualization applications do not have access to high performance systems for the computationally demanding visualization tasks. Rendering the visualization remotely and using a **thin client** (e.g. a web browser) to display the result allow users to access the visualization even on devices that do not target graphics processing. However, the flexibility to manipulate the data interactively suffers in thin-client configurations. This makes a meaningful interaction with data sets that contain many objects difficult. This is especially true in **in-situ visualization scenarios**, where direct interaction with the data can be challenging.

We tackle this problem with an approach that employs a deferred visualization pipeline to divide the visualization computation between a server and a client. Our thin client is built on web technologies (**HTML5**, **JavaScript**) and is integrated with the **JQuery** and **D3 libraries** to enable **interactive data-driven visualizations**. An intermediate representation of objects is introduced which describes the data that is transferred from the server to the client on request. The server side carries out the computationally expensive parts of the pipeline while the client retains extensive flexibility by performing object modification tasks without requiring an expensive re-rendering of the data.

DEFERRED VOLUME VISUALIZATION



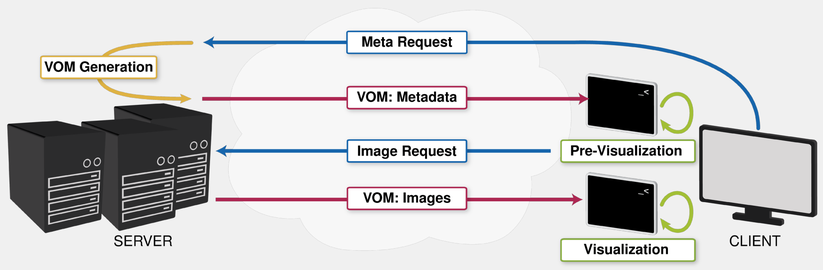
In **deferred rendering**, intermediate results of the rendering pipeline are written to buffers which are taken into account in a later stage for the generation of the final image.

Previous deferred visualization pipelines generated **proxy images** as a deferred representation for volume data [3]. Different types of proxies allow for a deferral of specific operations on the volume, such as relighting or limited viewpoint changes.

Our approach proposes a pipeline that **defers object-level manipulations** to the client-side by transmitting an intermediate volume representation.

OUR SYSTEM

We introduce a novel intermediate representation for deferred visualization. The Volume Object Model (VOM) consists of metadata and pre-rendered visualizations of each object in a data set.



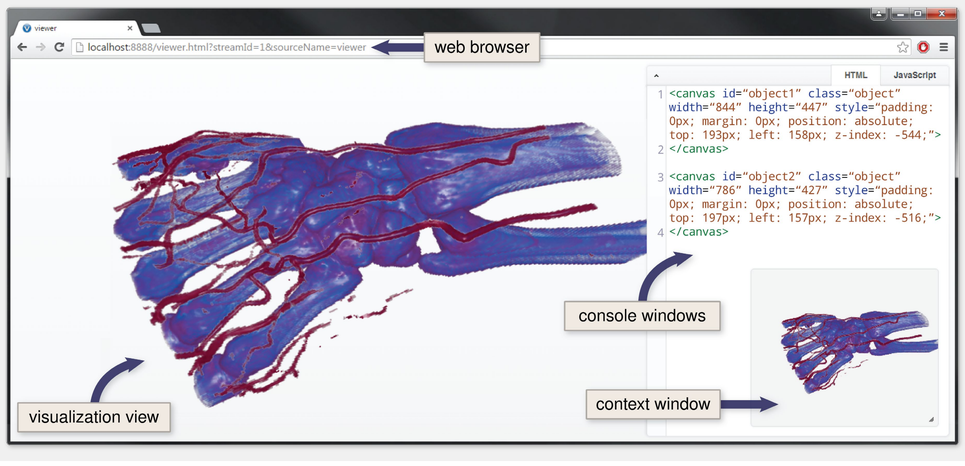
The architecture of our system. The server generates the Volume Object Model and transmits it to the web client on request through a socket-based streaming solution.

In order to guarantee client-side interactivity even for large data sets, the client receives only the **metadata** for a **pre-visualization step**.
By allowing the user to perform filtering, the complexity of the requested visualization data can be reduced from the client side before streaming any image data.

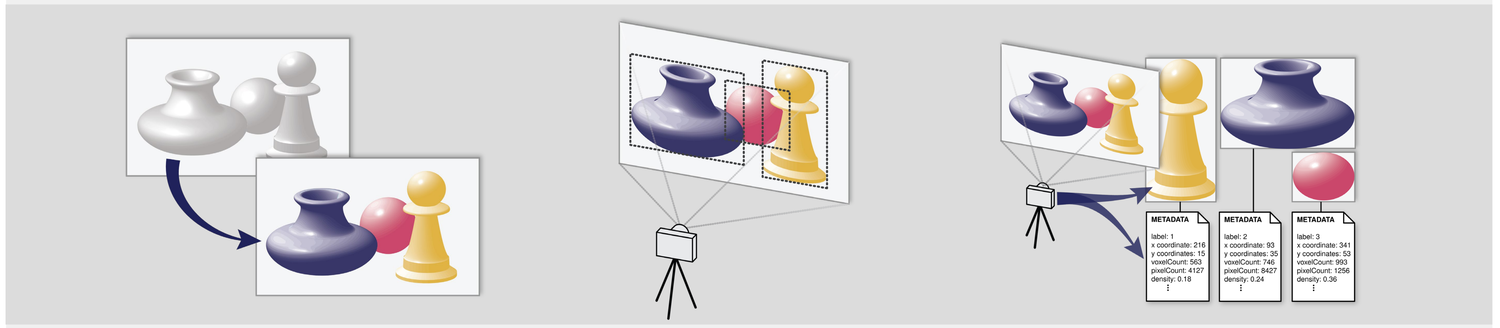
The **object images** are requested from the server on demand. In combination with the metadata, the **final visualization** can then be reconstructed from these images. Moreover, all objects in the visualization can be investigated and programmed by the user via an integrated console. No additional streaming of content is necessary unless the viewpoint or server-side visualization parameters are changed.

Our implementation is integrated with the **VolumeShop** [1] visualization framework. The volume rendering is performed using OpenCL.

The client (screenshot below) is accessed through any **web browser**.



VOLUME OBJECT MODEL



Segmentation *Boundary Computation* *VOM Generation*

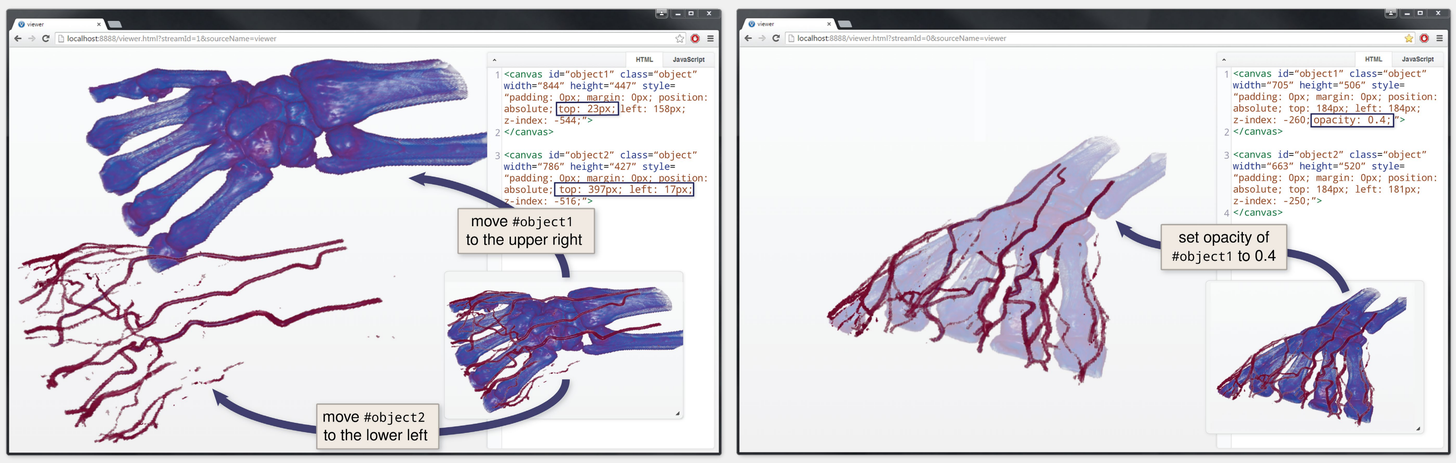
The server renders the Volume Object Model in three consecutive steps. First, the volume is segmented into objects using a **ViSlang** [2] script, which allows for the specification of **customized segmentation** parameters.

Then, the **screen-space bounding boxes** of each object are evaluated in a first pass over the volume. This allows us to create render targets for each of the objects.

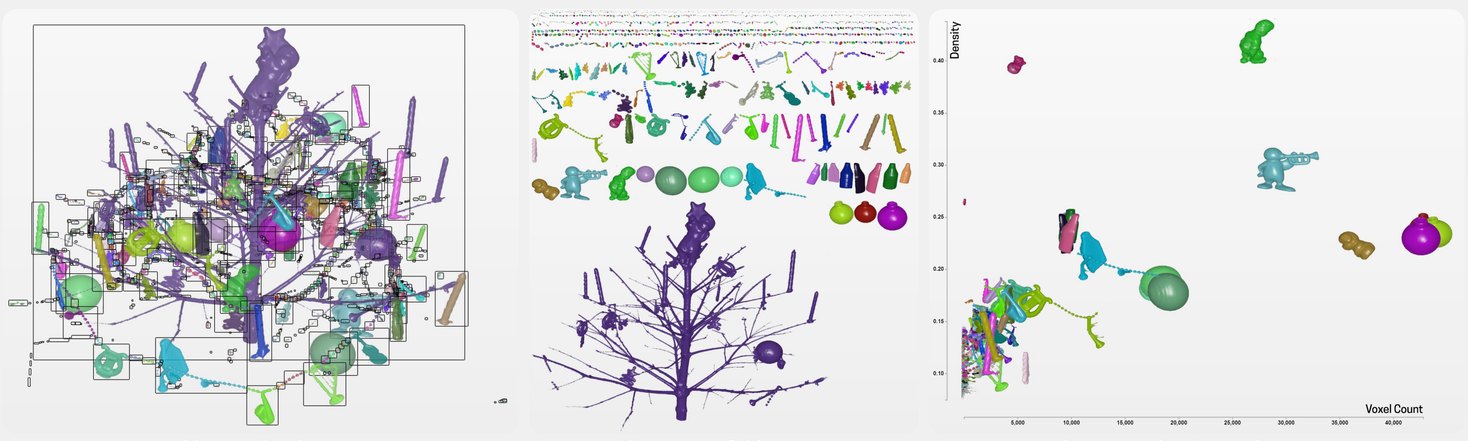
The objects are rendered to their respective **render targets** in a second pass over the volume independent of occlusion. Additionally, we gather **metadata** (e.g. scalar aggregates, geometric properties, topological information) about the objects.

INTERFACE & RESULTS

On the client side, each object is rendered to an HTML5 canvas element, which can be modified through JavaScript.



Our system enables the user to script modifications on the object level. Objects can be addressed by their unique ID or by classes, which can be assigned to objects. This permits users to modify individual objects as shown in the examples above, or write functions to query, filter, and apply modifications to groups of objects. In summary, our approach allows for the execution of fully interactive object-related visualization tasks in a web browser without triggering an expensive re-rendering on the server.



Object Outlines *Sorting of Objects* *Scatterplot Visualization*

Reconstructed visualizations of a decorated Christmas tree. On the left, we draw the borders of each object in the visualization. In the middle, we sort and arrange the objects according to their size. We can create complex visualizations from the objects and their metadata, e.g. arranging objects into a scatterplot according to specific features as shown on the right. Here, we plot voxel count vs. density and use each object as a glyph in the scatterplot. Our system allows the user to program object level manipulations on the client side with only a few lines of code.

REFERENCES

[1] Stefan Bruckner and M. Eduard Gröller. ***VolumeShop: An interactive system for direct volume illustration.*** In Proceedings of IEEE Visualization 2005, pages 671–678, 2005.

[2] Peter Rautek, Stefan Bruckner, M. Eduard Gröller and Markus Hadwiger. ***ViSlang: A system for interpreted domain-specific languages for scientific visualization.*** In IEEE Transactions on Visualization and Computer Graphics 20, pages 2388–2396, 2014.

[3] Anna Tikhonova, Carlos D. Correa, and Kwan-Liu Ma. ***Visualization by proxy: A novel framework for deferred interaction with volume data.*** In IEEE Transactions on Visualization and Computer Graphics 16, pages 1551–1559, 2010.

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جامعة الملك عبدالله للعلوم والتقنية
King Abdullah University of Science and Technology

CONTACT *a.fruehstueck@gmail.com*