Standards-compliant HTTP Adaptive Streaming of Static Light Fields

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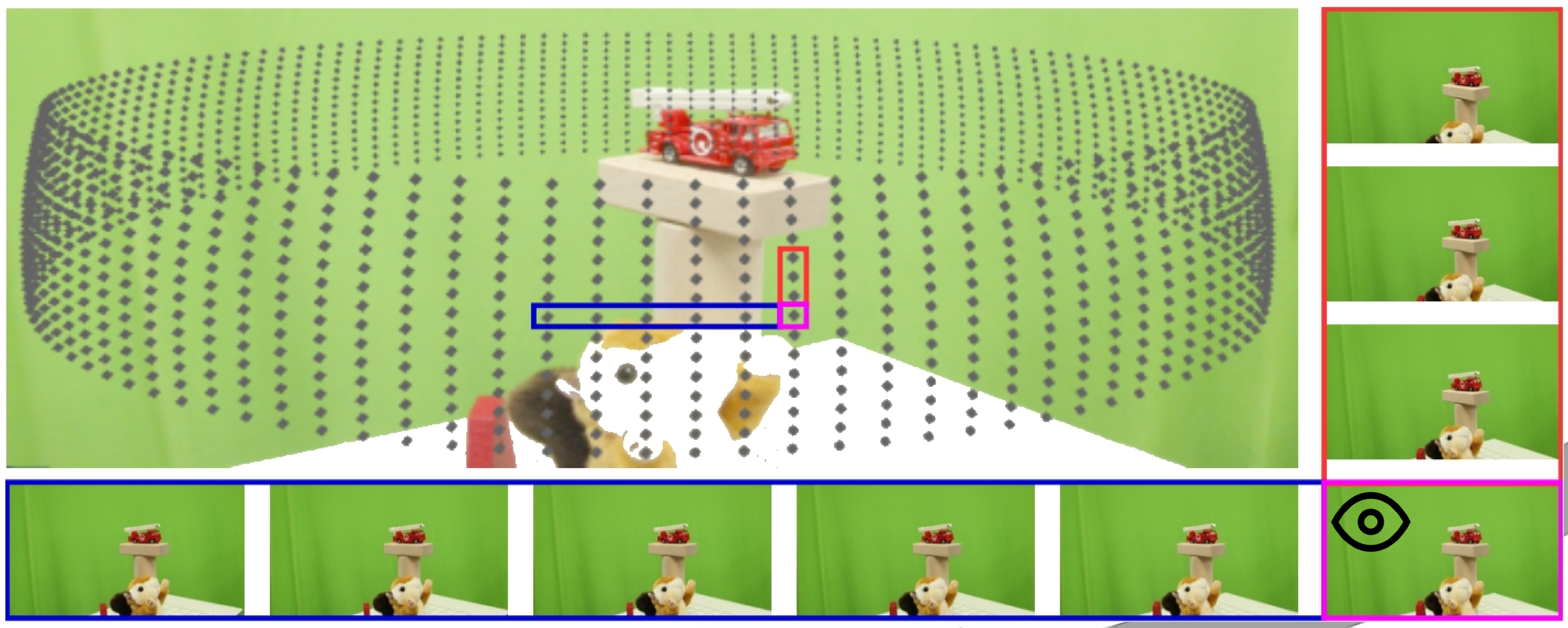
Static Light Fields

Static light fields (LFs) capture not only the intensity but also the direction of light rays in 3D space at a particular point in time. As such, they are an effective technology to **precisely visualize complex inanimate objects**, synthetic and real-world alike. LF technology is well suited for **consumption in AR / VR / MR**.

Large Data Sets

Static LFs are typically recorded as a **collection of 2D images**. This sampling method inevitably gives rise to **large data volumes**, which in turn hampers real-time light field streaming over best effort networks (e.g., the Internet)



Data Set Compression

Image compression algorithms (e.g., JPEG) fail to reduce LF data sets to acceptable sizes.

Video compression can be applied to a LF data set by encoding its constituting 2D images as a *pseudo-video*. In this approach, the visual similarity that is present in spatially adjacent LF image samples is converted into temporal redundancy.

Video compression helps to lower the storage requirements, but **how to tackle network streaming**?

Our Approach

We package the source images of a static light field as a **segmented video sequence** so that the light field can be **interactively** streamed over the network in a **quality-variant fashion** using the **MPEG-DASH** standard (Dynamic Adaptive Streaming over HTTP).

Maximized Interoperability and Deployment Potential

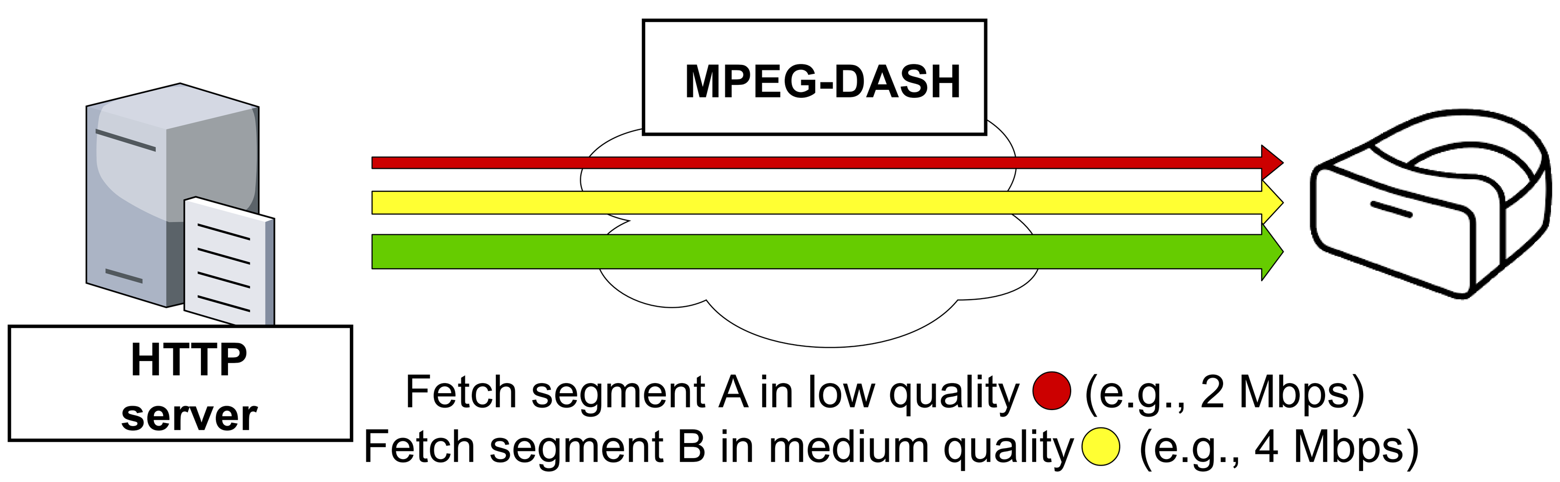
Our solution relies on a **mainstream, widely adopted video codec** (i.e., H.264) to compress the source views of static light fields. At client side, this approach allows the exploitation of **hardware-accelerated video decoding** functionality that is granted by **commodity GPUs** to attain **real-time rendering** performance.

Contributions

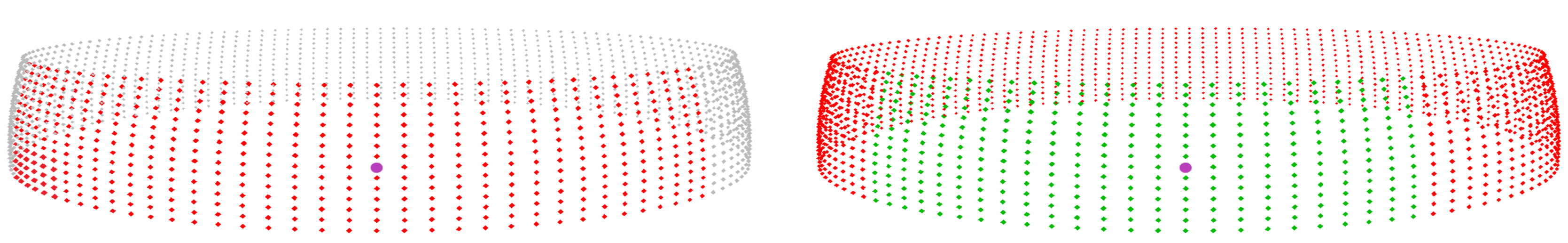
1. First rigorous study of adopting the **MPEG-DASH** standard to interactively and adaptively stream static light fields in HMD-supported VR.
2. The use of a vanilla video codec allows for **hardware acceleration** using consumer-grade GPUs, while the MPEG-DASH appropriation eases interoperability with existing clients.

Quality Adaptation Logic

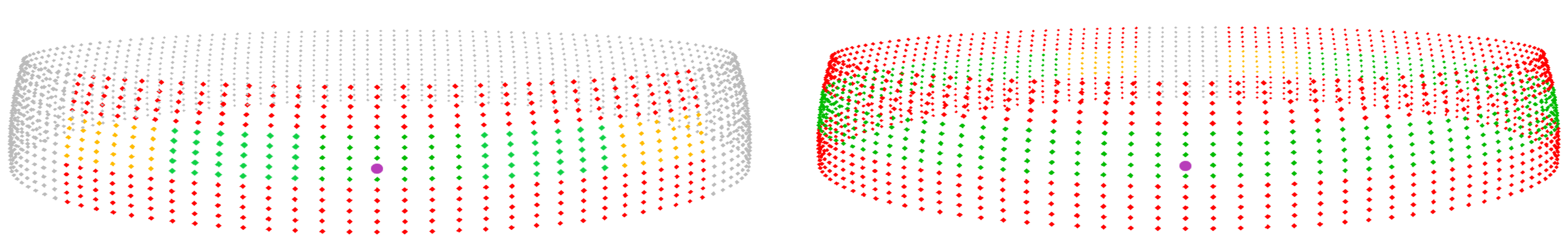
Our solution allows to selectively pick which video segments (each containing multiple LF source views) to stream and in what quality to do so, this way giving rise to **quality-variant random access** to specific spatial and angular portions of the light field. The adaptivity potential of our work is evidenced by **two Quality Adaptation Logic heuristics** that are each tailored to a specific VR application scenario.



Fetch segment A in low quality (e.g., 2 Mbps)
Fetch segment B in medium quality (e.g., 4 Mbps)
Fetch segment C in high quality (e.g., 6 Mbps)
...



Fast Fill heuristic accommodates fast moving users (i.e., quickly download full LF data set at lowest quality and then upgrade to highest quality)



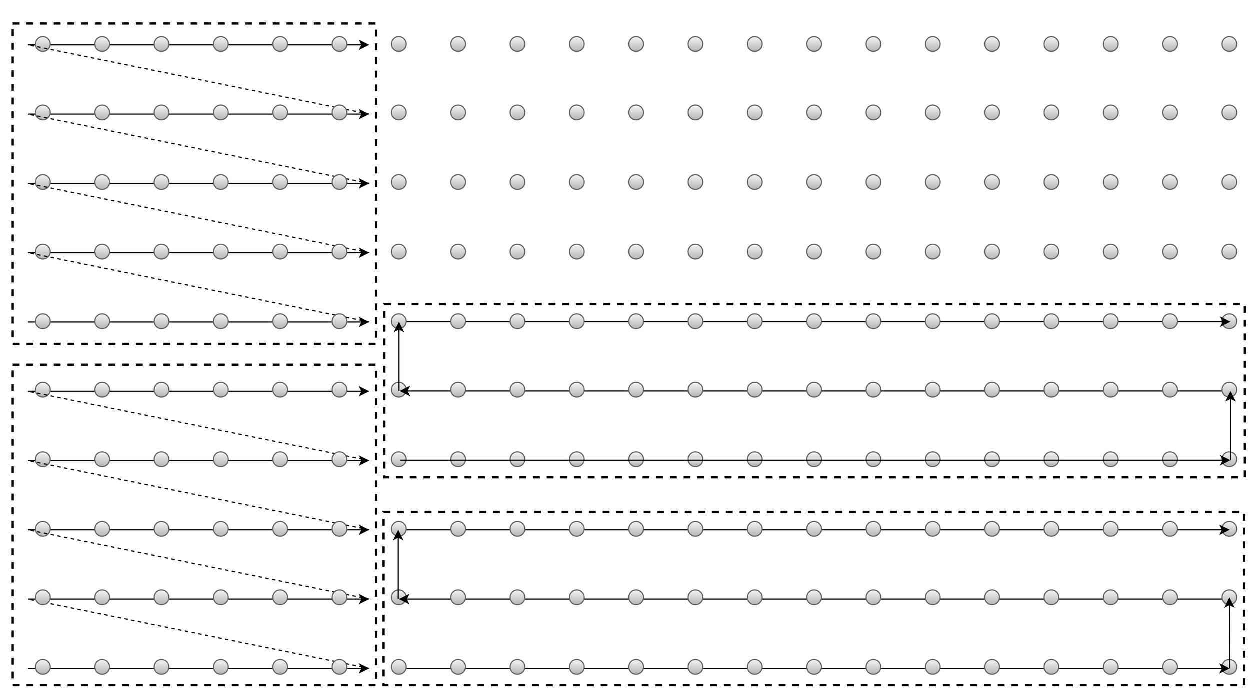
Steady Expansion heuristic prioritizes quality over source image download rate (i.e., immediately download LF data set in high(er) quality)

Source Image Sequencing and Segmentation

Three-dimensional problem space to find **optimal compression performance:**

1. Quantity of LF source views to include in a single MPEG-DASH segment?
2. What sequencing order to apply to these source views?
3. What spatial layout must MPEG-DASH segments adhere to (in terms of the light field sample locations they cover)?

30 views, raster scan sequencing, 6 x 5 rectangular layout



45 views, bidirectional sequencing, 15 x 3 rectangular layout

H.264 vs JPEG compression, expressed in average encoded image size in bytes:

		H.264 – QP 13			H.264 – QP 23			H.264 – QP 33			JPEG
	Layout	raster	diff	bidirectional	raster	diff	bidirectional	raster	diff	bidirectional	
firetruck	1×15	1,043,908	>0,53%	1,038,413	158,137	=0,00%	158,137	17,124	=0,00%	17,124	3,176,352
	15×1	1,043,082	>0,01%	1,042,989	153,965	>0,15%	153,740	15,553	>0,04%	15,547	
	6×5	1,047,024	>0,14%	1,045,567	155,791	>2,06%	152,618	16,332	>7,96%	15,081	
	10×3	1,046,697	>0,09%	1,045,788	154,703	>1,47%	152,447	16,052	>5,65%	15,170	
	3×15	1,057,080	<0,05%	1,057,611	152,108	<0,27%	152,521	15,676	>2,91%	15,227	
	15×3	1,058,617	>0,05%	1,058,066	153,396	>1,11%	151,703	15,775	>3,21%	15,276	
animal	15×1	2,450,295	>0,01%	2,450,083	353,767	>0,16%	353,195	31,206	<0,45%	31,347	3,534,966
	6×5	2,432,841	>0,07%	2,431,117	360,460	>1,17%	356,262	36,042	>3,65%	34,751	
	10×3	2,430,834	>0,03%	2,430,142	356,504	>1,00%	352,966	33,425	>1,96%	32,777	
	15×3	2,424,713	>0,03%	2,424,090	353,121	>0,87%	350,058	32,323	>1,17%	31,947	

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