

HoloCast+: Hybrid Digital- Analog Transmission for Graceful Point Cloud Delivery with Graph Fourier Transform

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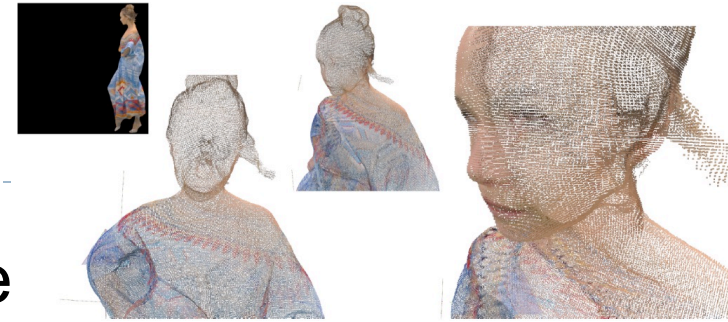


Background

- ▶ Volumetric media streaming
 - ▶ Reconstruct 3D scenes with full parallax and depth info.
 - ▶ Applications: entertainment, medical imaging, augmented reality
- ▶ Important technique for the post-COVID society
 - ▶ Realize 3D/holographic teleconference
 - ▶ Smooth communications between remote people

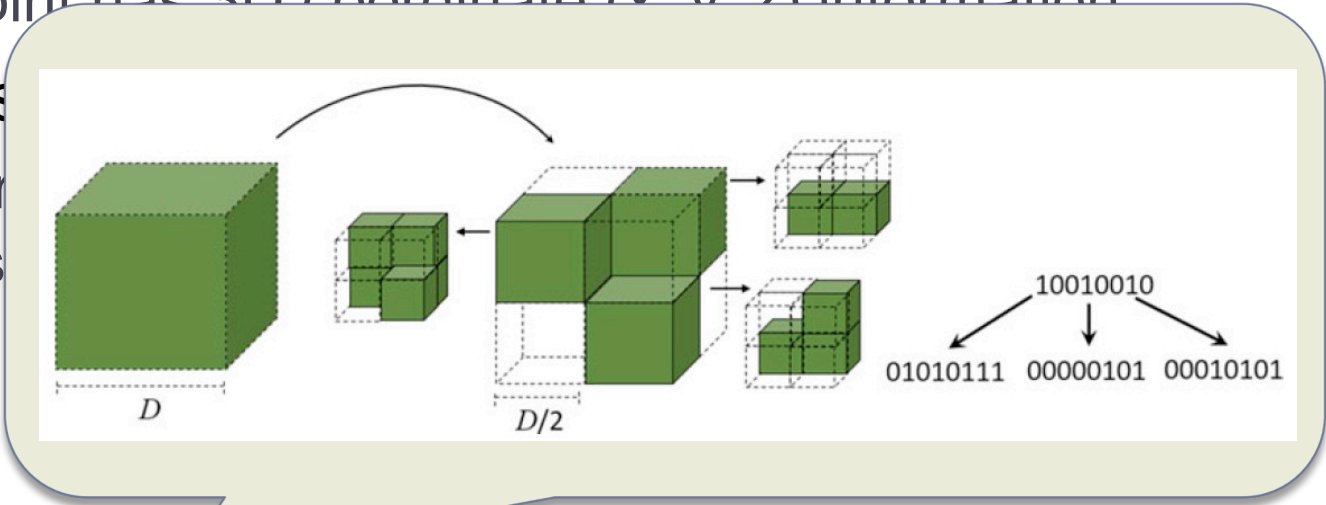


Point Cloud

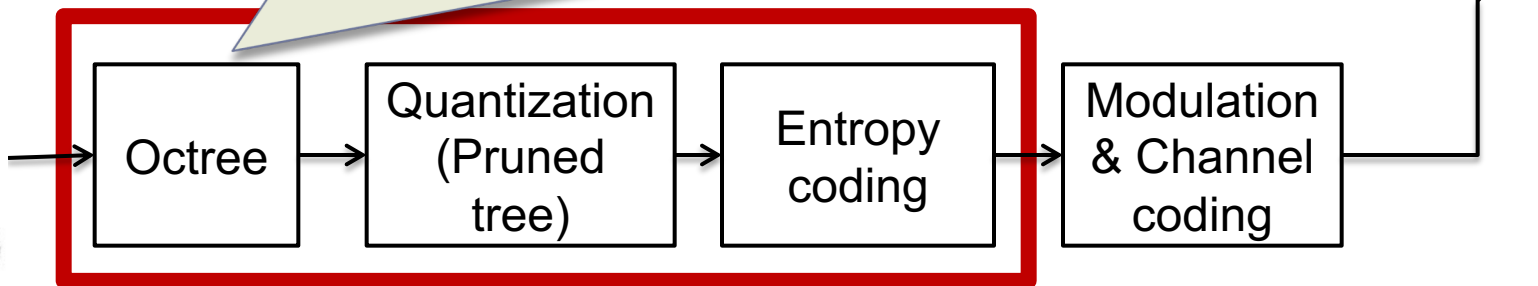
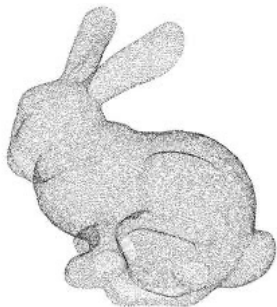


- Typical data structure for 3D scene
 - Consist of numerous and irregular structure of 3D points
 - Each point has 3D coordinate (x, y, z) information

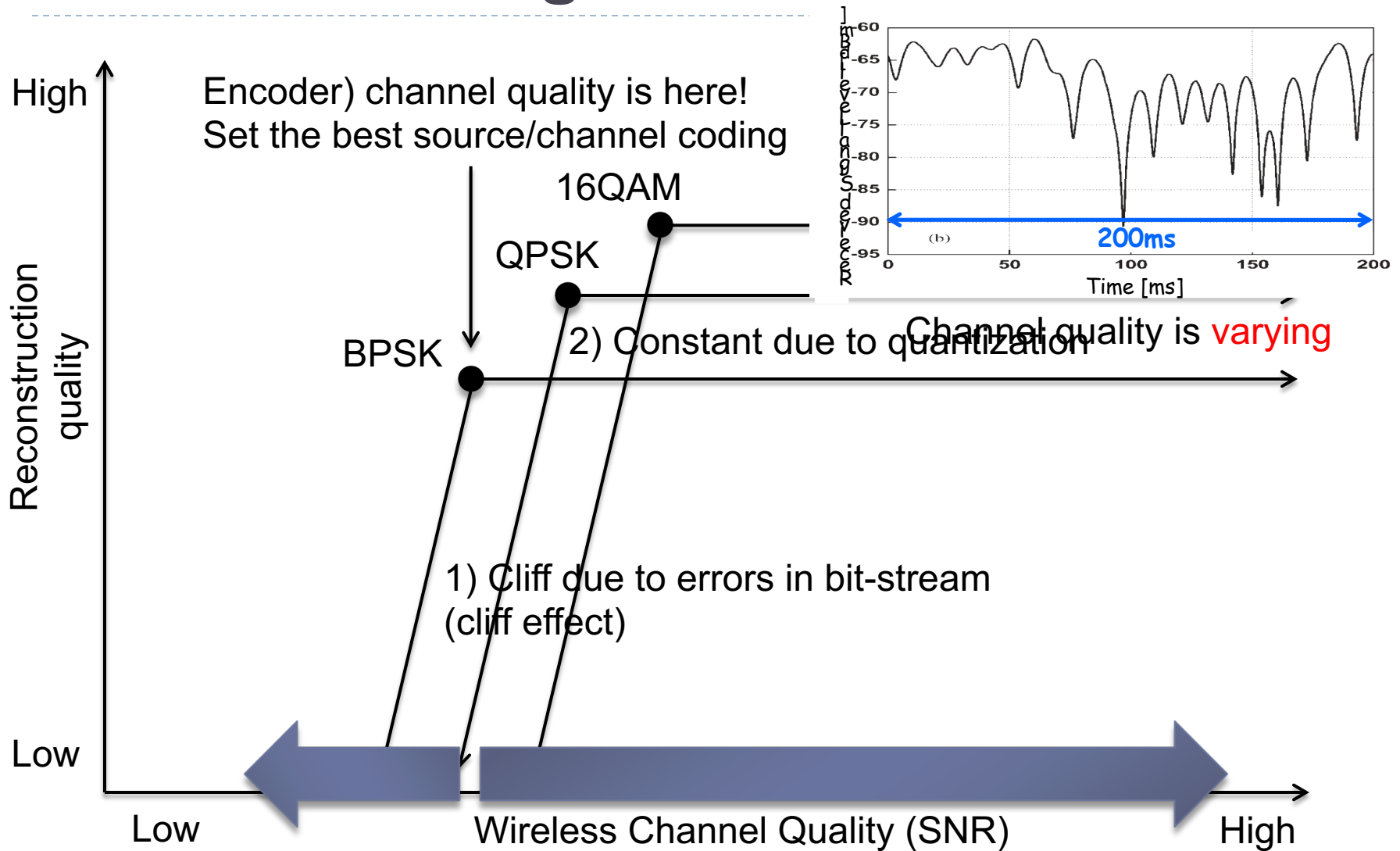
- Existing s
 - Encoder
 - wireless



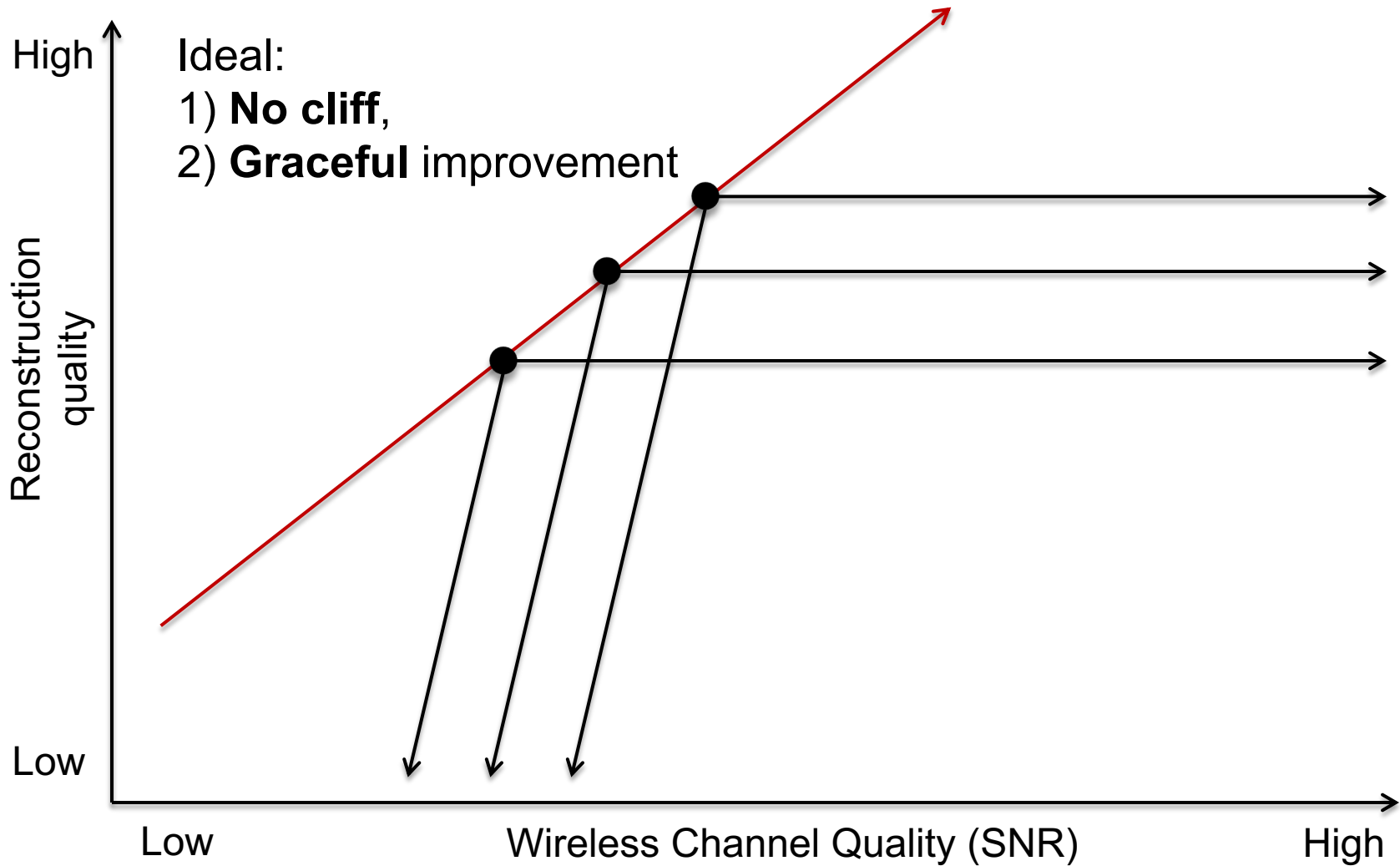
Point Cloud



Issues of digital-based wireless point cloud streaming

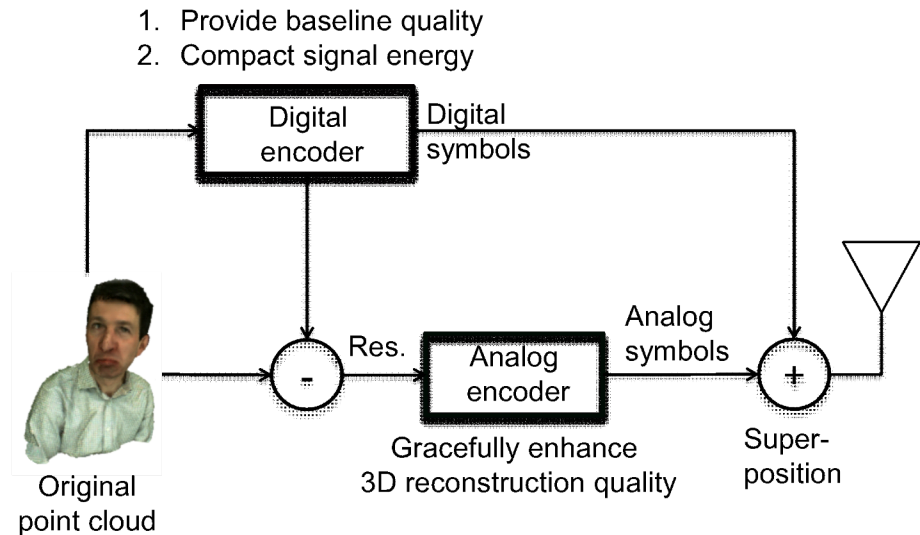


Goal



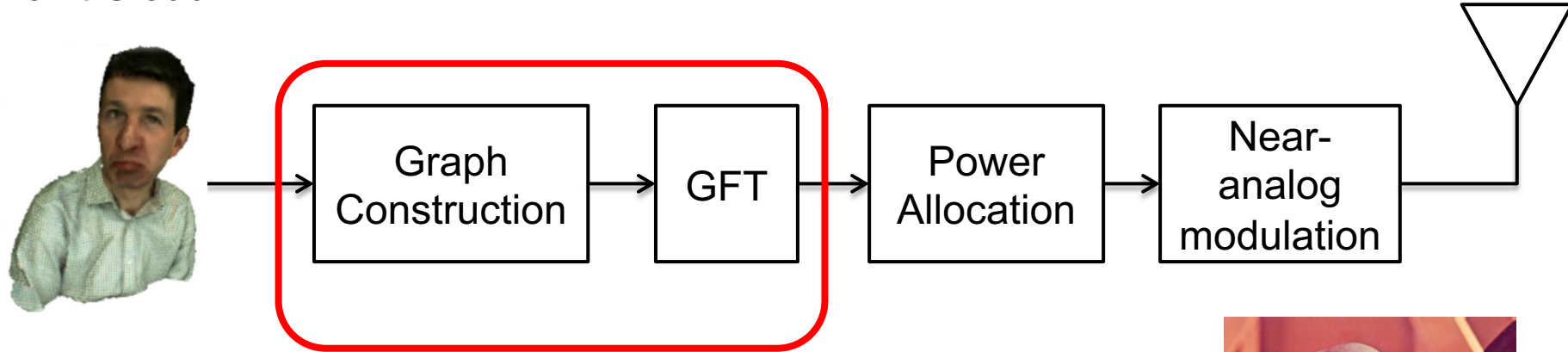
Purpose

- ▶ Our study tackles following challenging issues
 1. Prevent cliff effect
 2. Gracefully improve 3D reconstruction quality
- ▶ We propose novel schemes, **HoloCast** and **HoloCast+**, for wireless point cloud delivery
 - ▶ HoloCast [1]: first scheme to introduce **graph-based** analog coding for graceful point cloud delivery
 - ▶ HoloCast+: first scheme of **hybrid digital-analog (HDA)** point cloud delivery

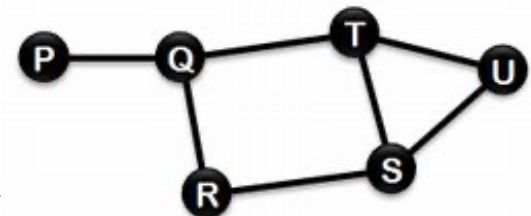
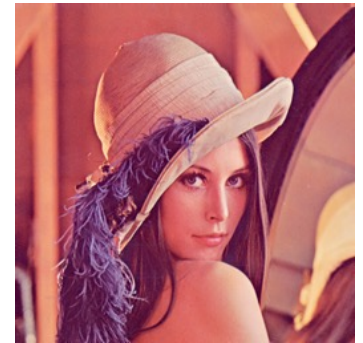


HoloCast [1] : Graph-based point cloud delivery

Original
Point Cloud

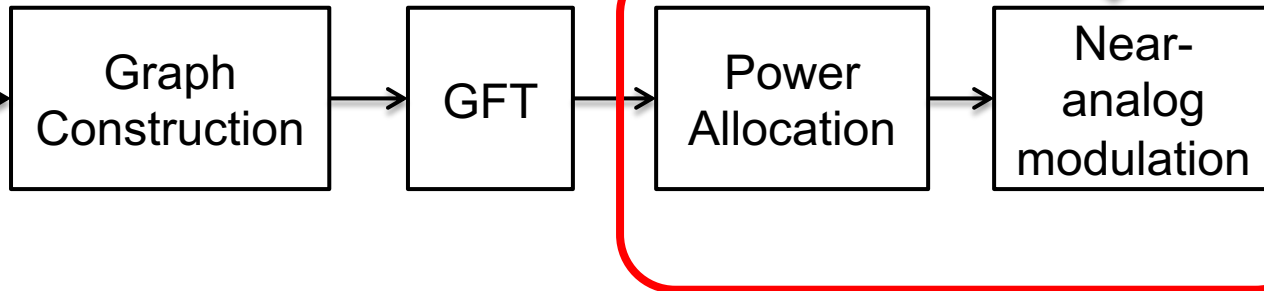


- ▶ Regard 3D points as graph signals
 - ▶ Conventional images and videos: horizontally and vertically ordered signals
 - ▶ Volumetric: non-ordered and irregular signals
- ▶ Introduce GFT for graph signals to exploit correlations in graph-domain

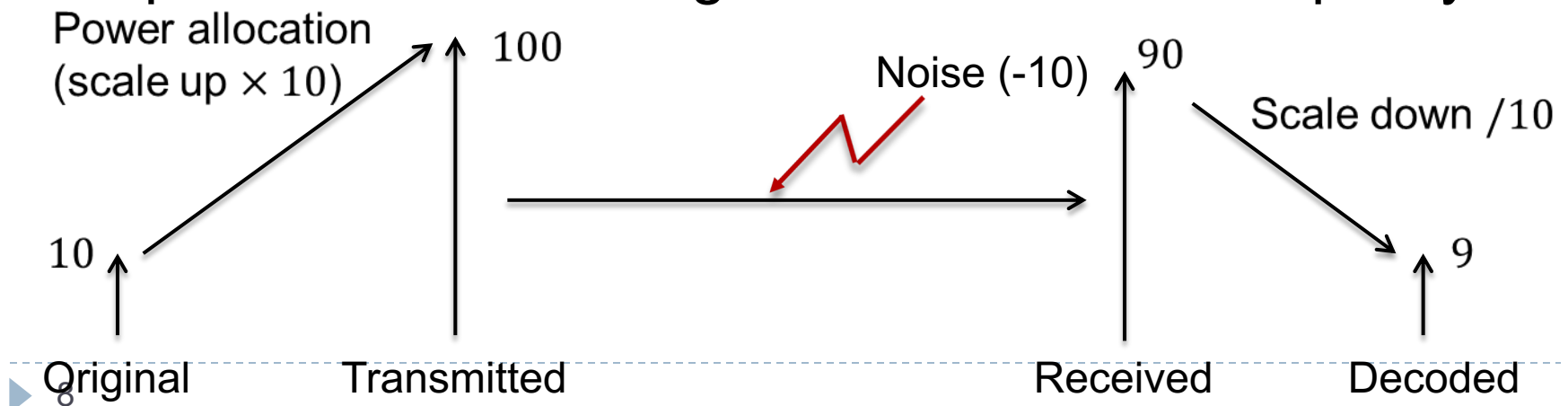


HoloCast [1] : Graph-based point cloud delivery

Original Point Cloud

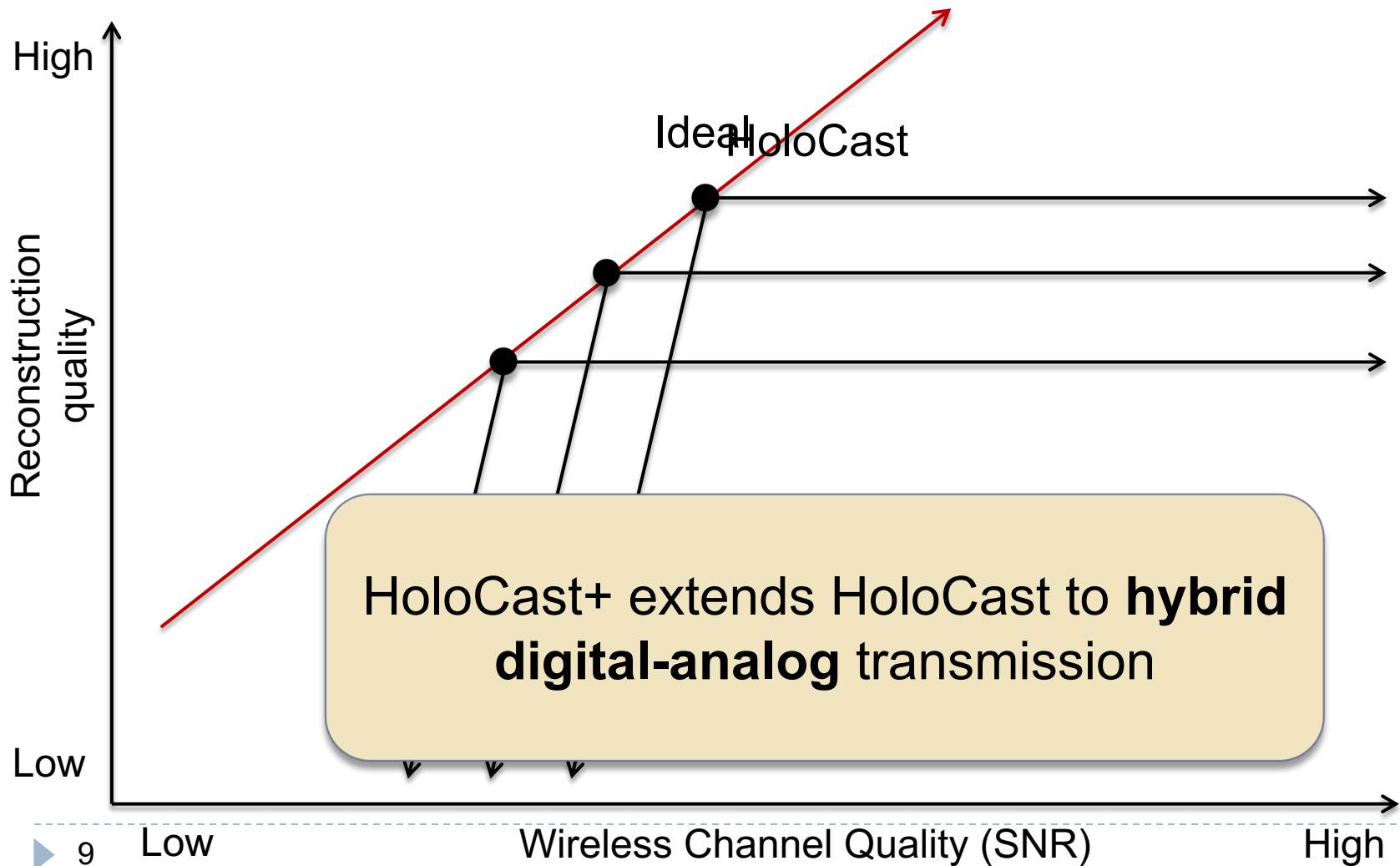


- ▶ Near-analog modulation realizes graceful quality improvement according to wireless channel quality



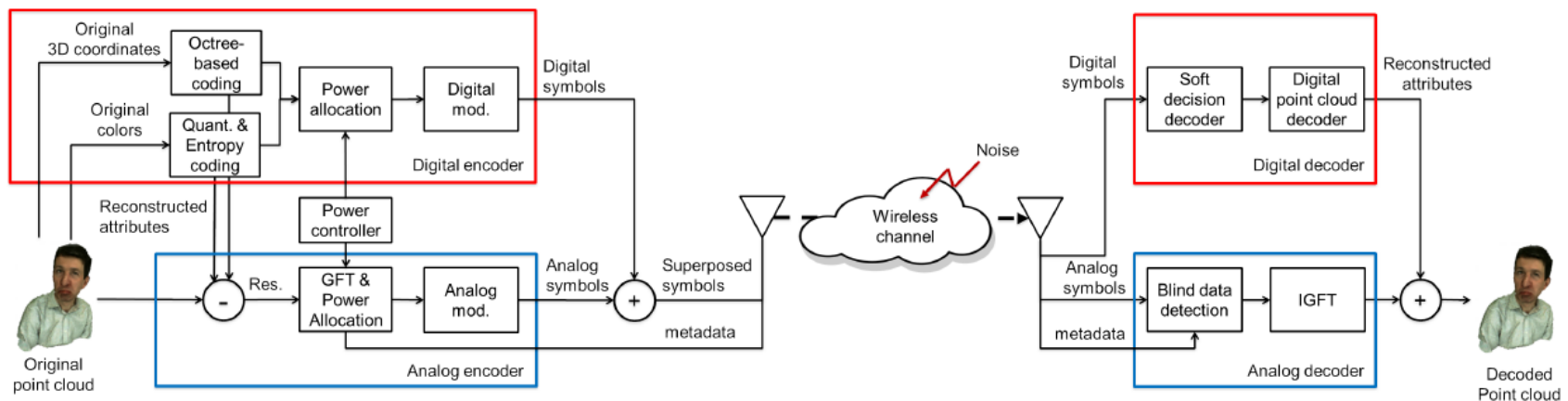
Issue of HoloCast

- ▶ Graceful, but **inefficient** owing to large signal energy



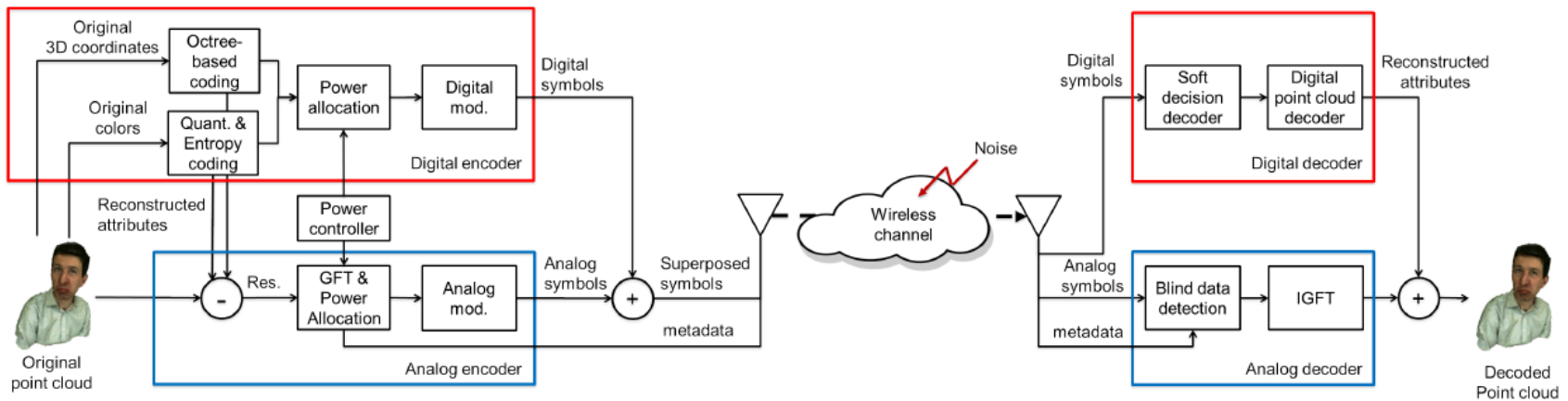
HoloCast+: Overview of sender

1. Encode point cloud to generate bit stream
 - ▶ Channel coded, interleaved, and modulated
2. Calculate **residuals** from original and reconstructed point cloud
 - ▶ Residuals are modulated by analog encoder
3. Assign transmission power to digital and analog symbols before superposition of both symbols



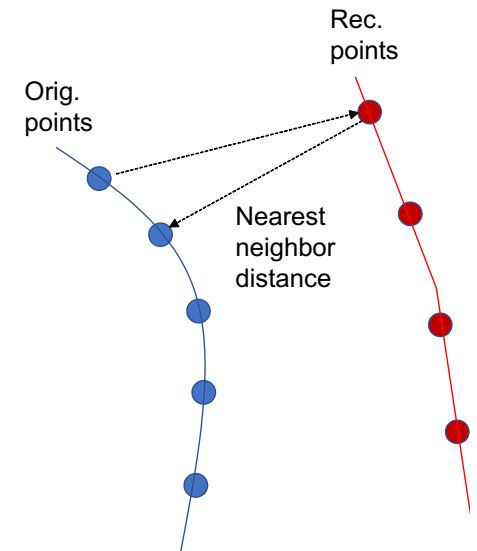
HoloCast+: Overview of receiver

1. Digital and analog symbols are decoded separately
 1. Soft decision decoder for digitally-modulated symbols
 2. Blind data detection for analog signal reconstruction
2. Add reconstructed residuals to the output from the digital decoder for final output

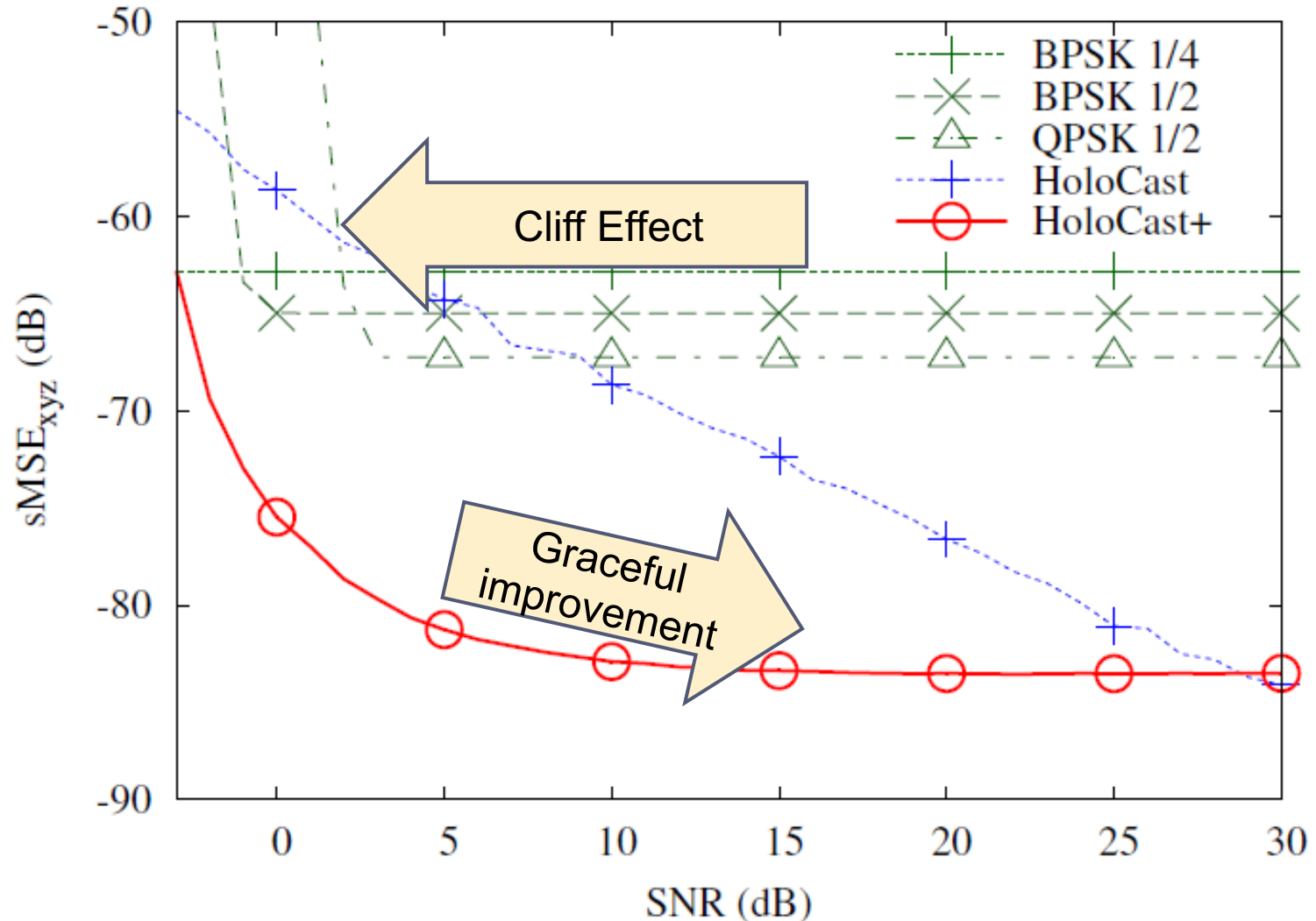


Evaluation

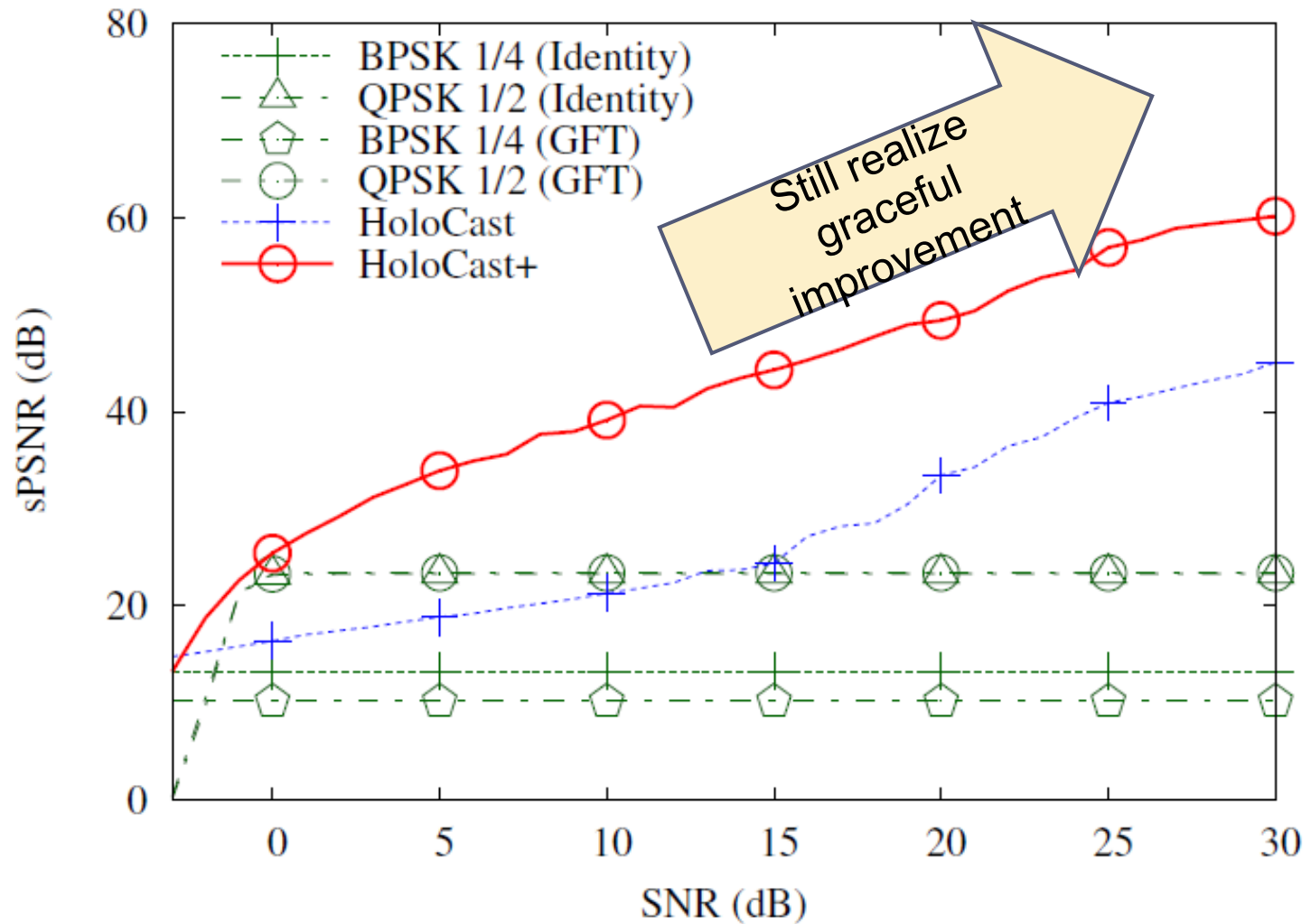
- ▶ Reference schemes
 - ▶ Digital-based: BPSK, QPSK
 - ▶ Use octree-based coding
 - ▶ Use rate-1/4 and 1/2 convolutional codes
 - ▶ HoloCast
 - ▶ HoloCast+ (Proposed)
- ▶ Reference point cloud
 - ▶ pencil 10_0 (2731 points)
 - ▶ pencil__9_0 (6712 points)
 - ▶ pencil__4_0 (5712 points)
 - ▶ pen__4_0 (23649 points)
 - ▶ milk_color (13704 points)
- ▶ Metric: symmetric mean square error (MSE) and peak signal-to-noise ratio (PSNR)



3D reconstruction quality of 3D coordinate attributes



3D reconstruction quality of color attributes



Visual Quality



Original



QPSK 1/2



HoloCast



HoloCast+

Conclusion

- ▶ We designed graceful point cloud delivery
 - ▶ HoloCast: first scheme to introduce graph-based analog coding for graceful point cloud delivery
 - ▶ HoloCast+: first scheme of HDA point cloud delivery
- ▶ Potential applications
 - ▶ AR, VR, 3D display, LiDAR
 - ▶ 3D/Holographic teleconference
- ▶ Question? – Welcome!
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