SpinVR: Towards Live-Streaming 3D Virtual Reality Video

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Live-Streaming VR
Live-Streaming VR
Computational Burden

Raw Data: 10’s of Gb/sec

Compute time: 10’s of seconds / frame
in data center
Live-Streaming VR Cameras

Z-Cam V1 Pro
Calibration
Artefacts

Transparency, reflections

Occlusions, flow mismatches

[Anderson2016]
Artefacts

Fine structures

Too close

[Anderson2016]
SpinVR

Omnidirectional Stereo Video

[Peleg 2001, Richardt2013]
Omnidirectional Stereo

Left Eye

Right Eye

widely used by YouTube VR, Google Daydream, Facebook, ...
Line scan cameras
175° lenses
Rotary stage
Servo motor
Slip ring
Pipeline Comparison

Minimal capture BW
Minimal compute
→ Solves artefact issues*
→ No calibration*
*Some new challenges
*New design space

ODS

Camera Array

Data Capture
Image Processing
Optical Flow Computation
View Synthesis
Compositing
1) Seamless Rendering
2) Warping at the Poles

\[ \Delta \theta = \tan^{-1} \left( \frac{R/r}{\cos \phi} \right) \]

\[ \Delta \phi = \tan^{-1} \left( \frac{\sin \phi}{\sqrt{(R/r)^2 + \cos^2 \phi}} \right) - \phi \]
2) Warping at the Poles
3) Design Tradeoffs

Outdoor: 1 sensor per eye allows excellent quality
Indoor: More sensors / tradeoffs are needed

- Bright Indoor Lighting - 1,000 lux
  - 26 dB: acceptable
  - 32 dB: excellent

- Sunny Day - 10,000 lux
  - 1 sensor
  - 4 sensors
Prototype
SNR Validation

8192 x 4096 x 1/26 fps  4096 x 4096 x 1.11 fps  2048 x 4096 x 16.67 fps
SNR Validation

8192 x 4096 x 1/26 fps
4096 x 4096 x 1.11 fps
2048 x 4096 x 16.67 fps
Challenging Scenes

Google Cardboard Camera App

Vortex

Too close
Challenging Scenes

Reflections
Transparency
Occlusions
Fine structure
Vertical Nonuniform Sampling
Horizontal Nonuniform Sampling
Future Directions

Smaller & more cameras
Optical offlink
→ Higher FPS
Alternative optics

[aggarwal2016]
Conclusions

Streaming VR
Low computational cost
Resilient to common artefacts

Dewarping at poles
Perceptual saliency
SNR analysis