Characterization of 360° videos

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Motivation

› AR/VR are becoming popular
  › 22 million people experiencing VR monthly\(^1\)
  › more engaging and interesting for the user

› Foundation of AR/VR is 360° videos

› Off-the-shelf hardware and software for content creators
  › 360° camera hardware
  › Automatic stitching software

› Many companies/websites serving 360° videos

› We focus on streaming 360° videos in this work

Introduction

Only a portion of the video is viewed


https://www.youtube.com/watch?v=sT0hVLEe5mU
Problem

- 360° videos take more bandwidth
  - Higher resolution: 360° videos cover all spatial directions
  - Portions out of the field-of-view are wasted

- Before doing any adaptation, we want to see what 360° videos look like

- **Goal:** understand the characteristics of 360° videos and their implications on the network
Measurement Study

- Collected dataset of 4600 YouTube 360° and regular videos
  - Duration
  - Resolution
  - Bit rate
  - Motion vector

- Calculated effective resolution of 360° videos based on field-of-view

- Measured variability of bit rates over time of 360° and regular videos

- Compared the motion vectors of 360° and regular videos
Methodology

Looking for comparable 360° and regular videos

- Youtube has a big dataset for both 360° and regular videos

Extract videos in the same category/genre:

1. Youtube search
   Keyword: 360
   Filter: 360

2. Extract categories from most frequent words in titles

3. Youtube search
   Keyword: category name

- We ensured both regular and 360° videos have the same number of videos in each category

<table>
<thead>
<tr>
<th>Category</th>
<th># of Videos</th>
<th>Category</th>
<th># of Videos</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>2285</td>
<td>Roller coaster</td>
<td>325</td>
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<tr>
<td>Animals</td>
<td>216</td>
<td>Scenery</td>
<td>315</td>
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<td>Cartoon</td>
<td>197</td>
<td>Shark</td>
<td>24</td>
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<td>Concert</td>
<td>67</td>
<td>Skydiving</td>
<td>70</td>
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<td>122</td>
<td>Space</td>
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<td>Sports</td>
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<td>180</td>
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<tr>
<td>Movie trailer</td>
<td>131</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

# videos in each category
360° Videos are short:
- new medium
- complex to produce
Resolution

DASH: multiple resolutions of each video stored on server

360° videos have more resolutions

360° videos tend to have higher resolutions
What is the bit rate of the maximum resolution?

High bit rates for 360° video
Effective Resolution based on Field of View

Map projection: equi-rectangular

- A naïve calculation would be: \( \frac{90^\circ}{180^\circ} \times \frac{110^\circ}{360^\circ} = 15\% \) of total area
- Poles require more tiles for delivering
- Averaging over all possible head movements, the effective resolution is 22\% of the overall resolution
- Effective bit rate of 360° videos is similar to bit rate of regular videos

How does bit rate vary over time?

- per-second bit rate of the middle 10 minutes of the video
- normalize the per-second bit rate by the average bit rate of each video

Bit rate variability of regular videos > 360° videos
The average bit rates in 360° videos are almost static while regular videos have dynamic bit rate average. → More variability.

High-motion category has higher bit rate.
Motion characteristics

- per-frame motion vector magnitude of the middle 10 minutes of the video

Motion vector magnitude and variability of regular videos > 360° videos

Regular videos have large motions due to camera pans, rotations, etc.
Motion characteristics (Contd.)

High-motion category has greater average magnitude

Regular videos motion vectors > 360° videos motion vectors
Motion characteristics (Contd.)

(a) Horror 360°
(b) Skydiving 360°
Conclusion

- Measurement study of 360° and regular videos from YouTube

- 360° videos: shorter, more resolutions, higher resolutions

- Bit rate of 360° videos
  - Bad news: Higher bit rate
  - Good news: Less bit rate variability
  - Solution: Higher bit rate can be mitigated by viewport adaptation
    - Tradeoff between bandwidth (fetch more tiles) and latency (change set of tiles)

- Motion of 360° videos
  - 360° videos have less motion
    - Inherent movements in the scene only, no camera panning