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Characterization of 360° videos

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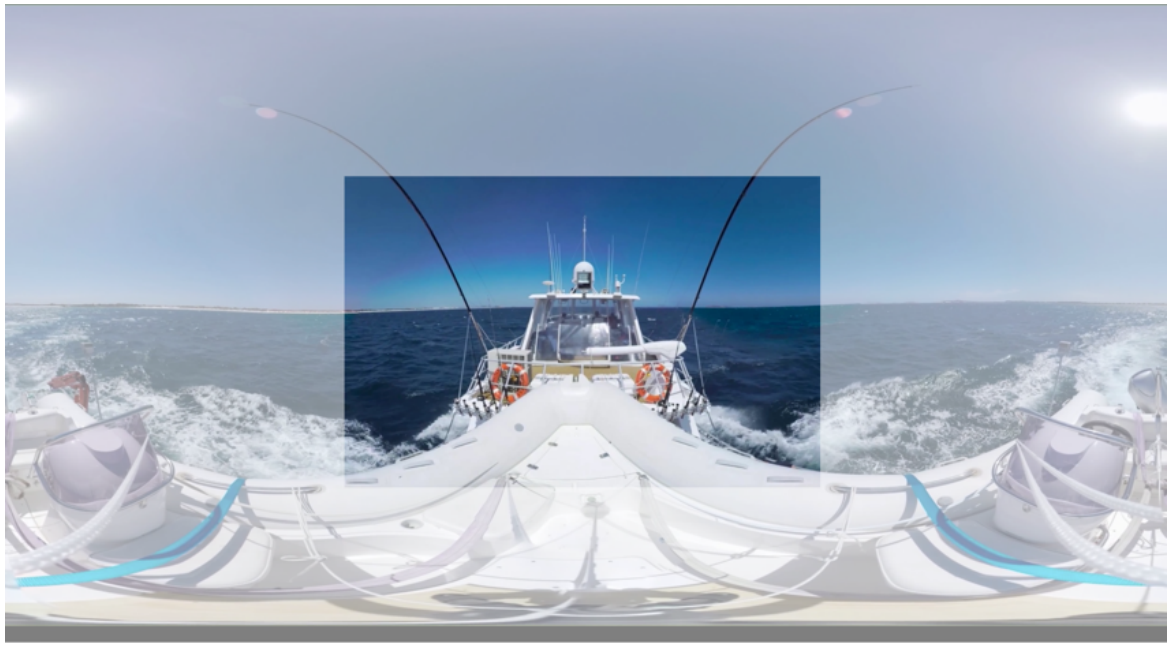
Motivation

- 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

1. http://variety.com/2017/digital/news/vr-headset-data-mau-2017-2019-1202440211/

Introduction



Only a portion of the video is viewed

http://www.samsung.com/ae/discover/images/linked/2016-05-02-img4.jpg

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

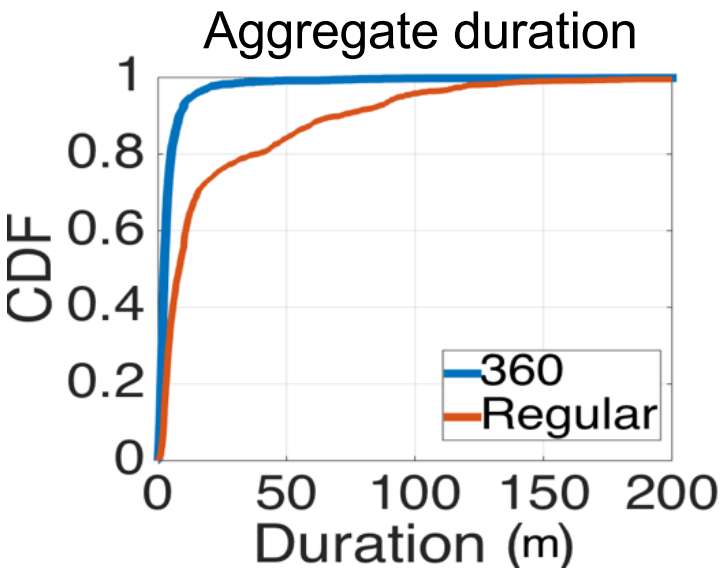
- Looking for comparable 360° and regular videos
  - Youtube has a big dataset for both 360° and regular videos
- Extract videos in the same category/genre:

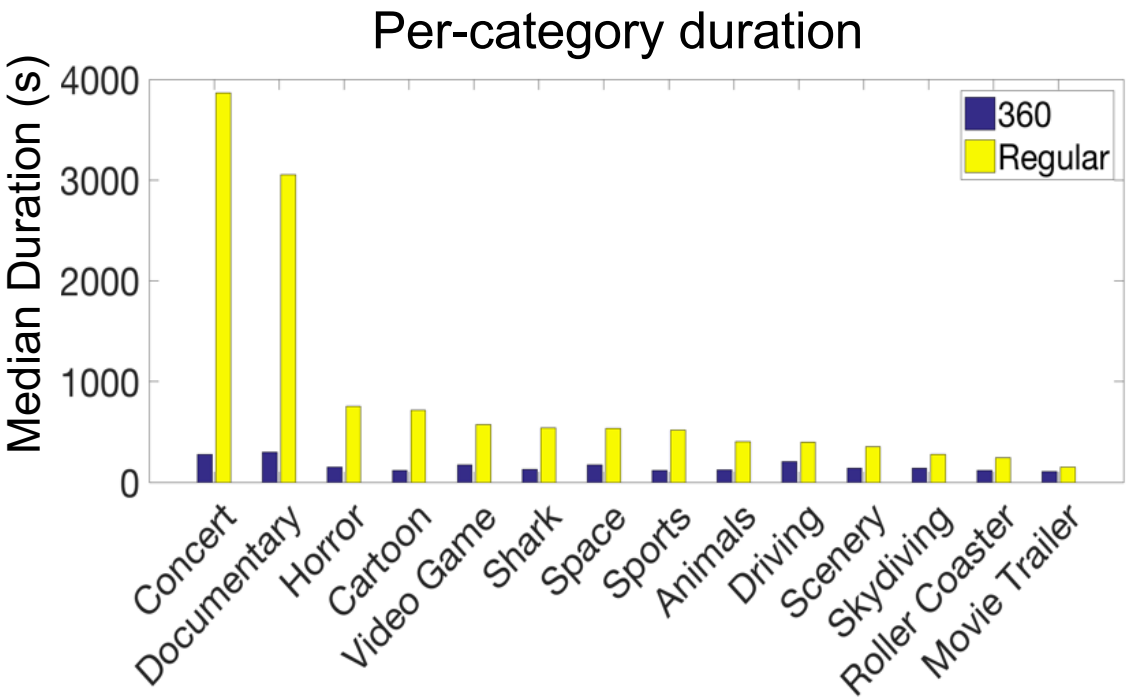
Category	# of Videos	Category	# of Videos
All	2285	Roller coaster	325
Animals	216	Scenery	315
Cartoon	197	Shark	24
Concert	67	Skydiving	70
Documentary	122	Space	126
Driving	176	Sports	139
Horror	180	Video game	197
Movie trailer	131		

videos in each category

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

Duration

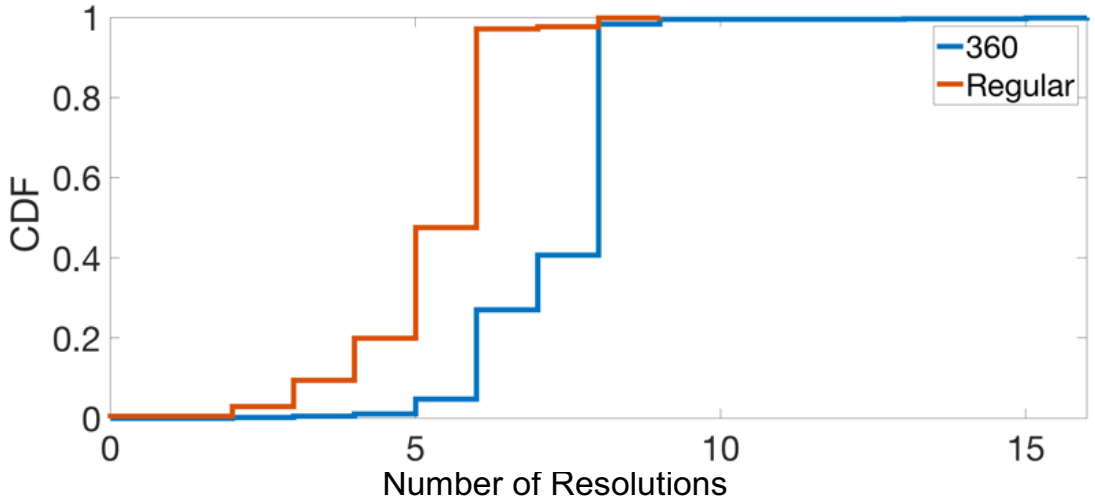




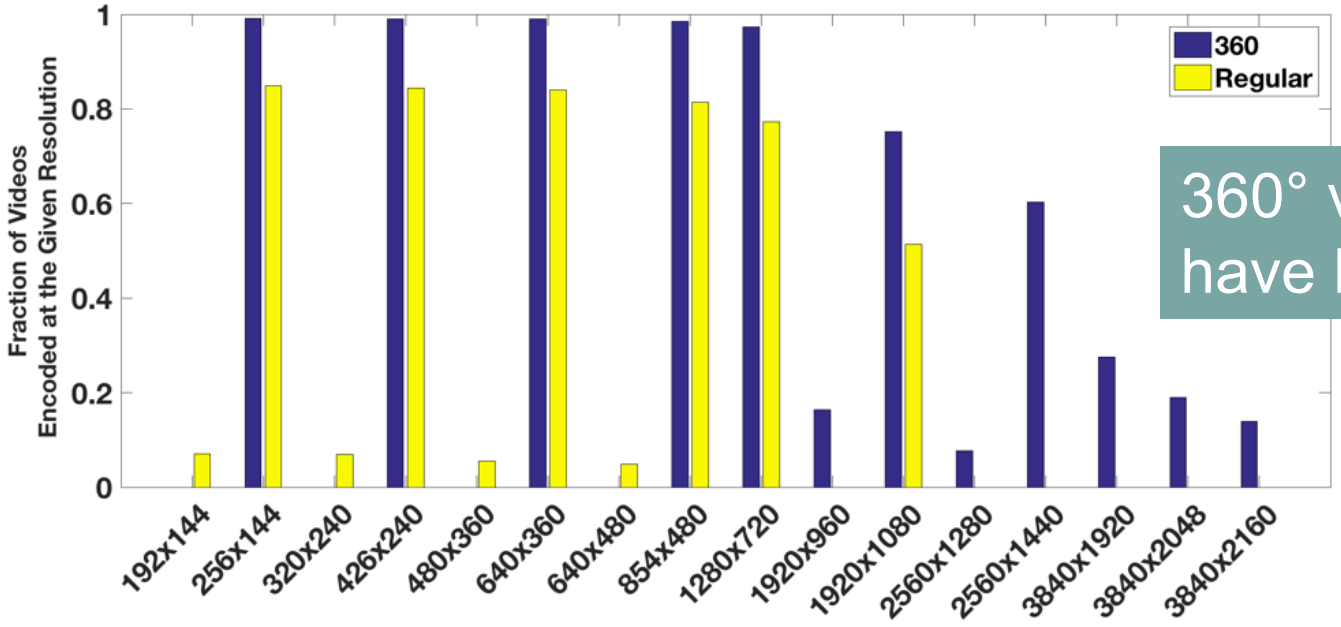
360° Videos are short:
- new medium
- complex to produce

Resolution

DASH: multiple resolutions of each video stored on server



360° videos have more resolutions

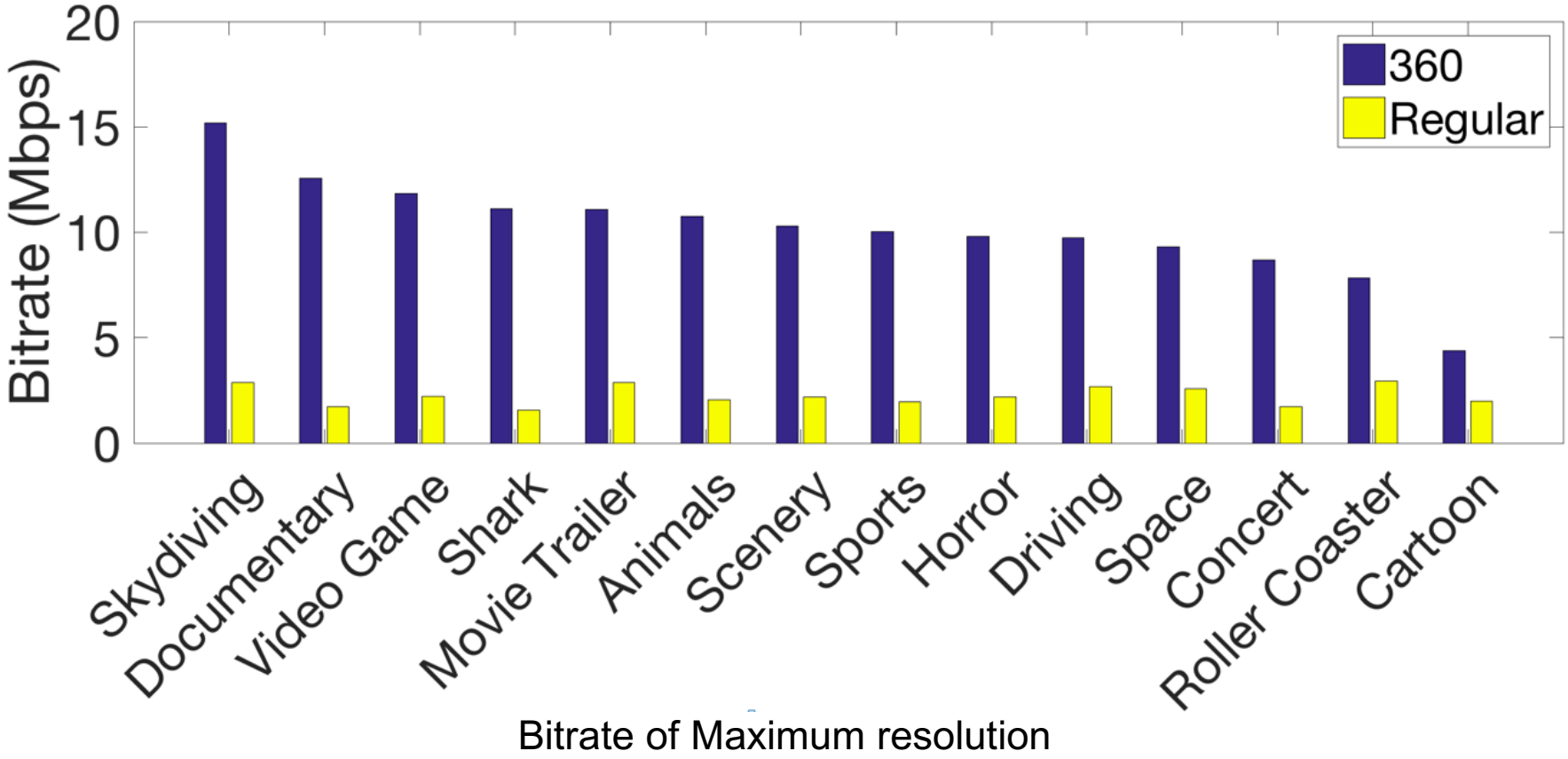


360° videos tend to have higher resolutions

Fraction of videos encoded at the given resolution

Bit rate

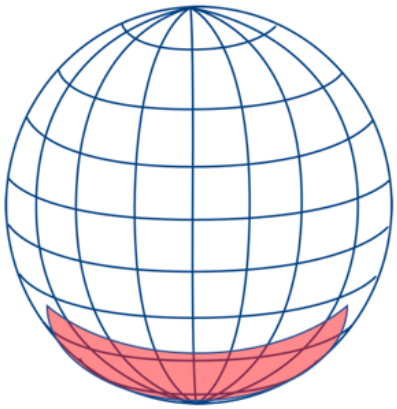
- What is the bit rate of the maximum resolution?

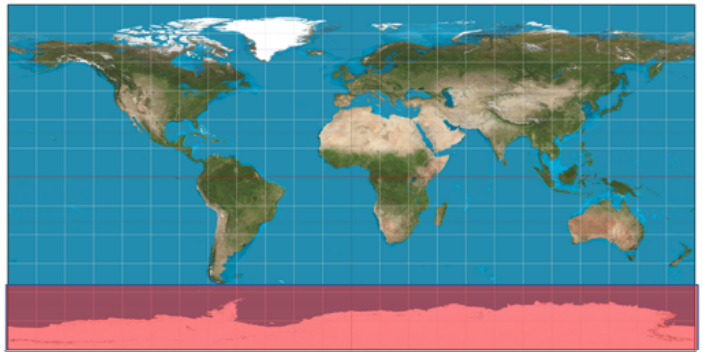


Bitrate of Maximum resolution

High bit rates for 360° video

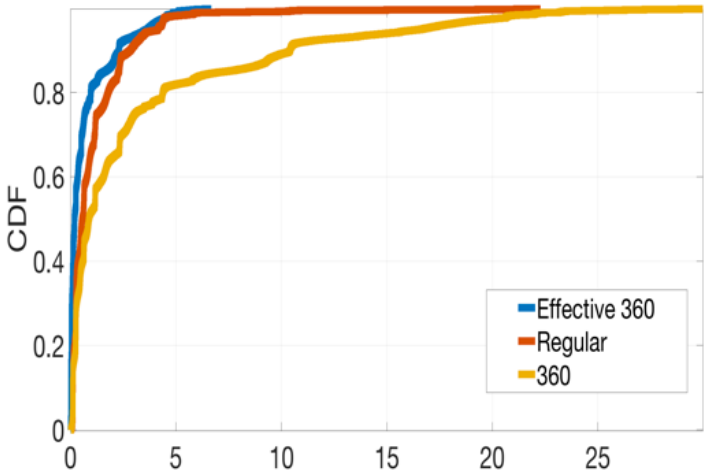
Effective Resolution based on Field of View





By Strebe - Own work, CC BY-SA 3.0[1]

Equi-Rectangular projection



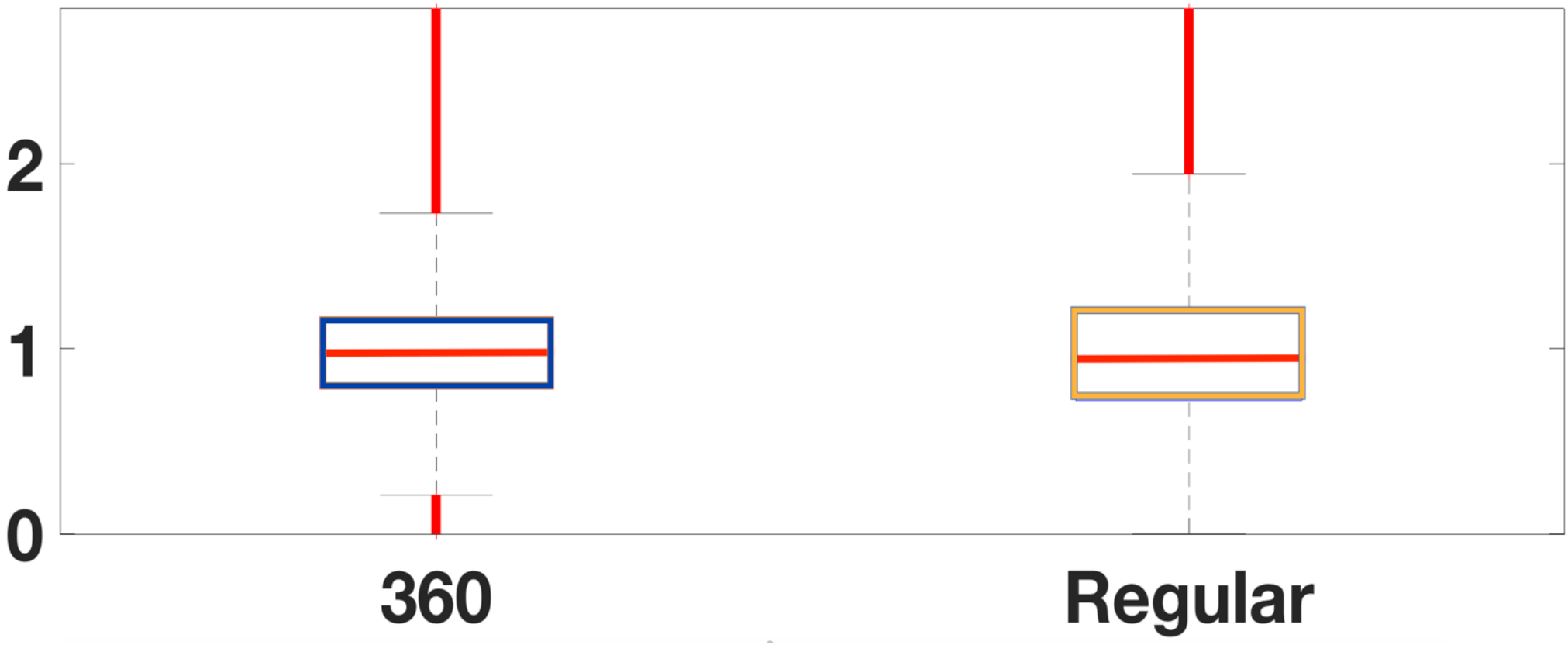
Bit rate(Mbps)

- Map projection: equi-rectangular
  - A naïve calculation would be : $\frac{90°}{180°} \times \frac{110°}{360°} = 15\%$ 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

1. https://commons.wikimedia.org/w/index.php?curid=16115228

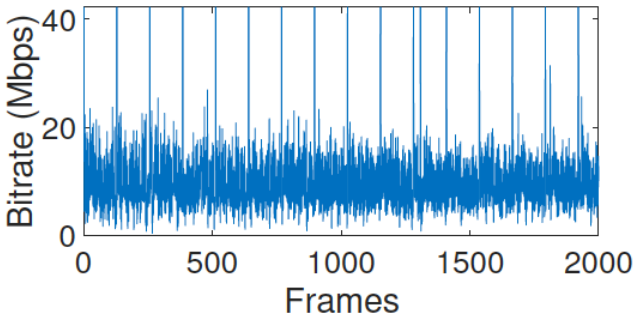
How does bit rate vary over time?

- 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

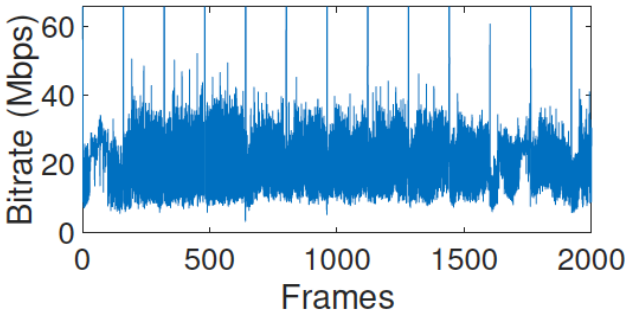


Bit rate variability of regular videos > 360° videos

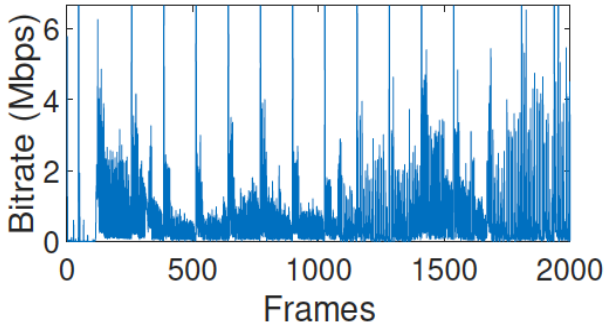
Time series of video bit rate



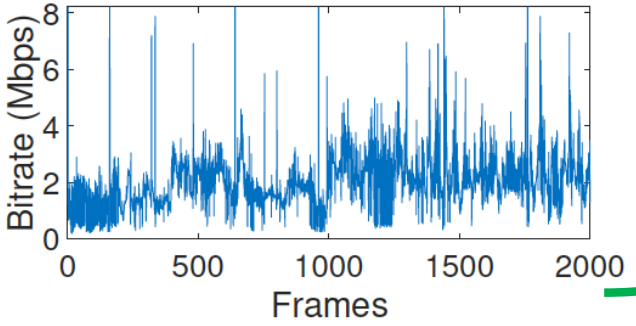
(a) Horror 360°



(b) Skydiving 360°



(c) Horror regular



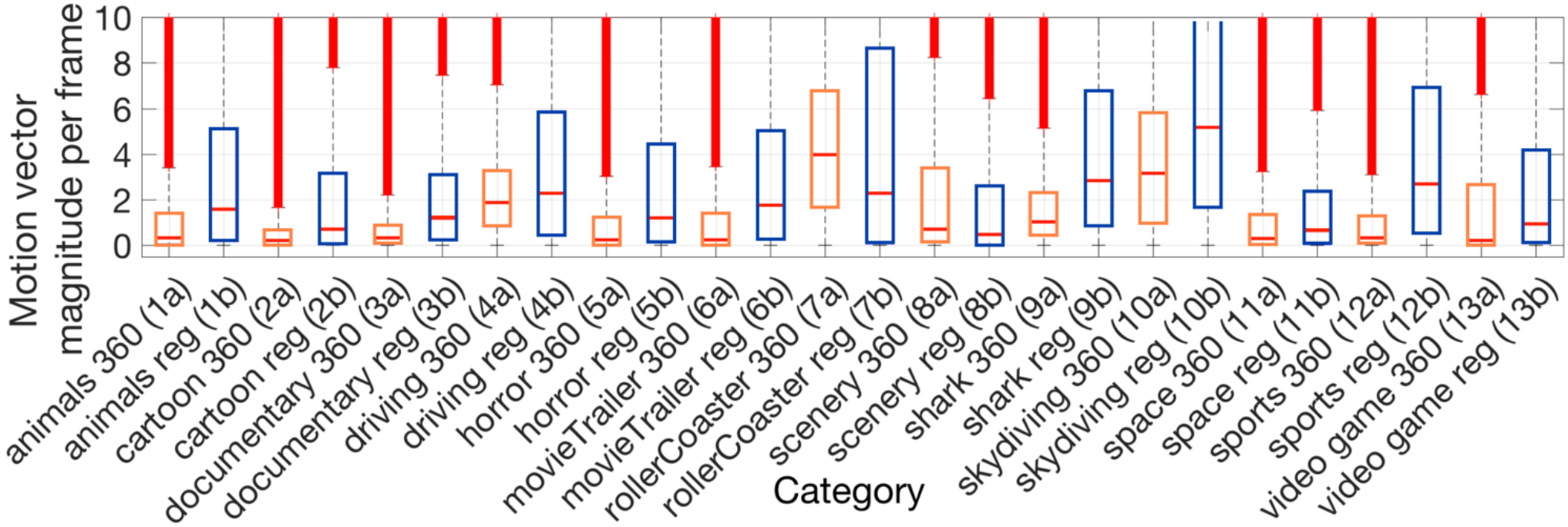
(d) Skydiving regular

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

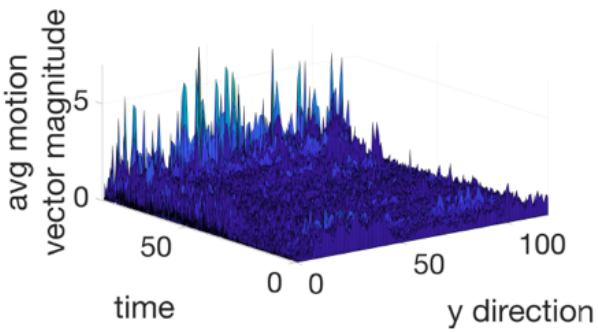
- per-frame motion vector magnitude of the middle 10 minutes of the video



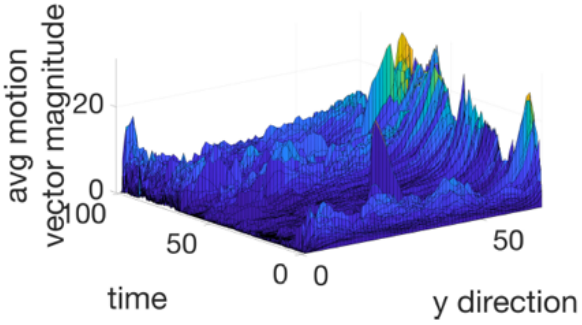
Motion vector magnitude and variability of regular videos > 360° videos

Regular videos have large motions due to camera pans, rotations, etc.

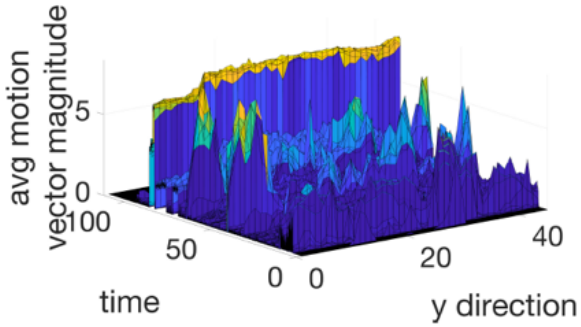
Motion characteristics (Contd.)



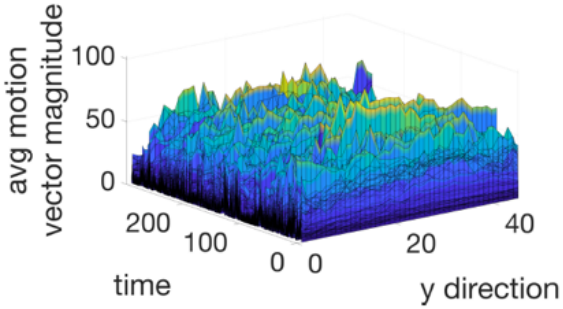
(a) Horror 360°



(b) Skydiving 360°



(c) Horror regular

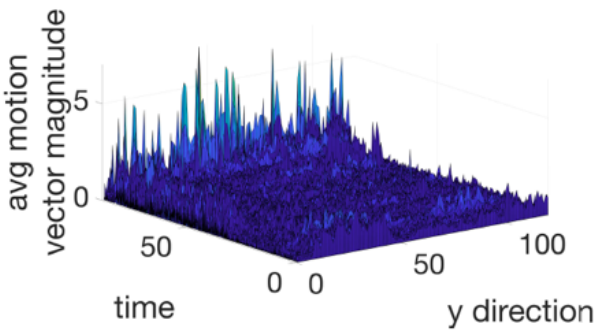


(d) Skydiving regular

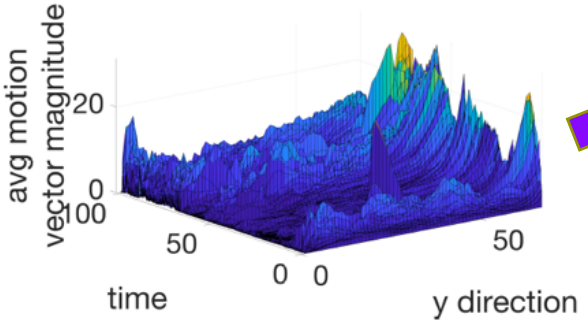
Regular videos motion vectors > 360° videos motion vectors

High-motion category has greater average magnitude

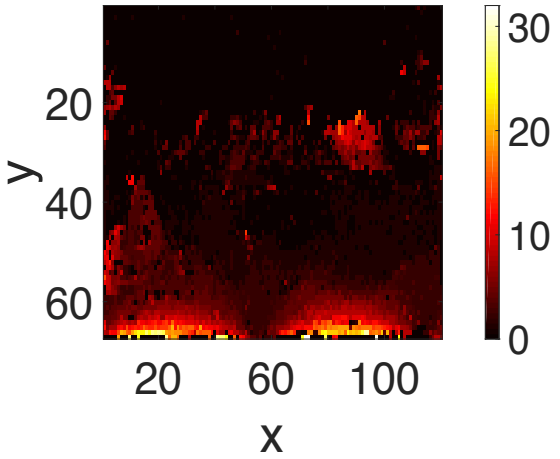
Motion characteristics (Contd.)



(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