Impacts of internal HMD Playback Processing on Subjective Quality Perception

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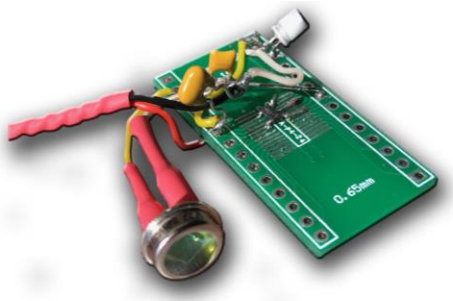
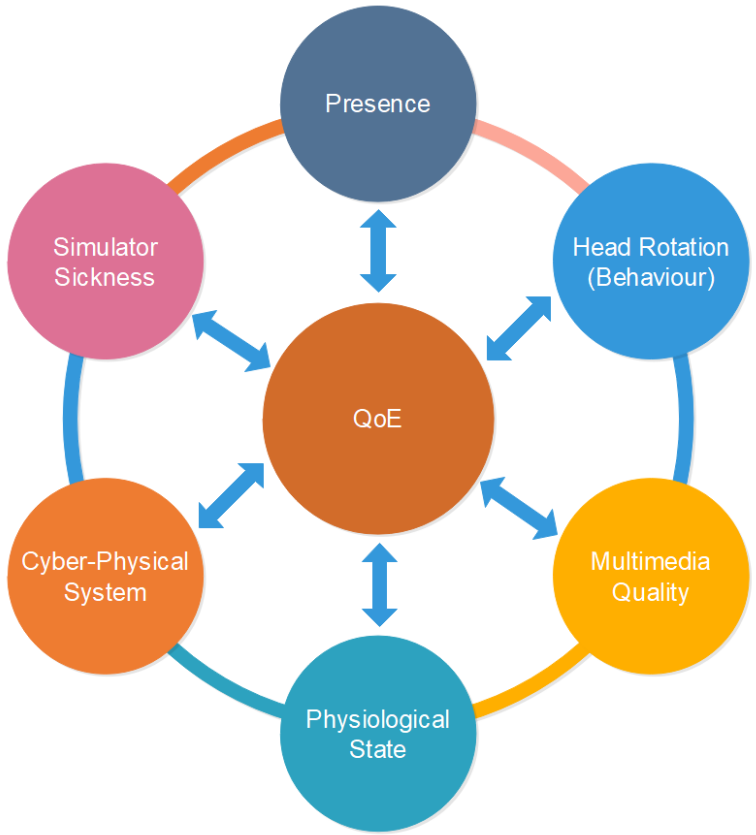
Motivation




LeCroy MSO 104MXs-B Mixed Signal Oscilloscope 1 GHz 10 GS/s
Trigger
Horizontal
Vertical
Adjust
Cursors

Scope

- Various factors influencing 360° video QoE
- Studies on subjective & objective quality evaluation for 360° videos
- Some studies on impacts of framerate for traditional 2D videos
- Important: How smooth are motions appearing to the user?
- Hypothesis: Smoothness important for high subjective quality
- Key questions:
  a) Influence of internal playback processing of HMD on displayed content?
  b) Use motion interpolation (MI) for improving 360° QoE?
  c) If yes: which algorithm to use to achieve higher QoE? Content-dependency?



Experimental Setup & Test Method – Flicker Test (1)

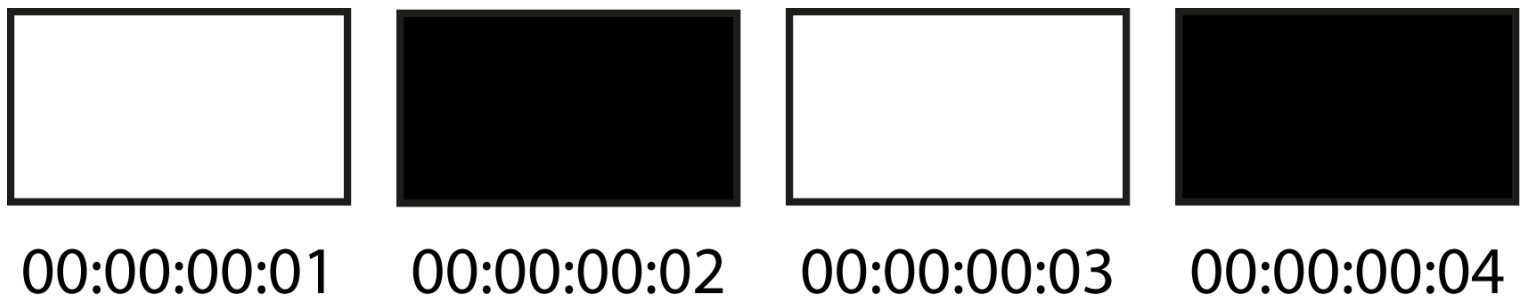
- Key question: Influence internal playback processing on content shown?
- Refresh rate Vive Pro = 90 Hz
- Effect of 30 fps (25/50/60/90 fps) 360° content playout?
- SteamVR installed on fresh VR PC
- Vive Pro considered as blackbox

→ Influence of 360° video player

  - GoPro VR player
  - Virtual Desktop
  - Whirligig

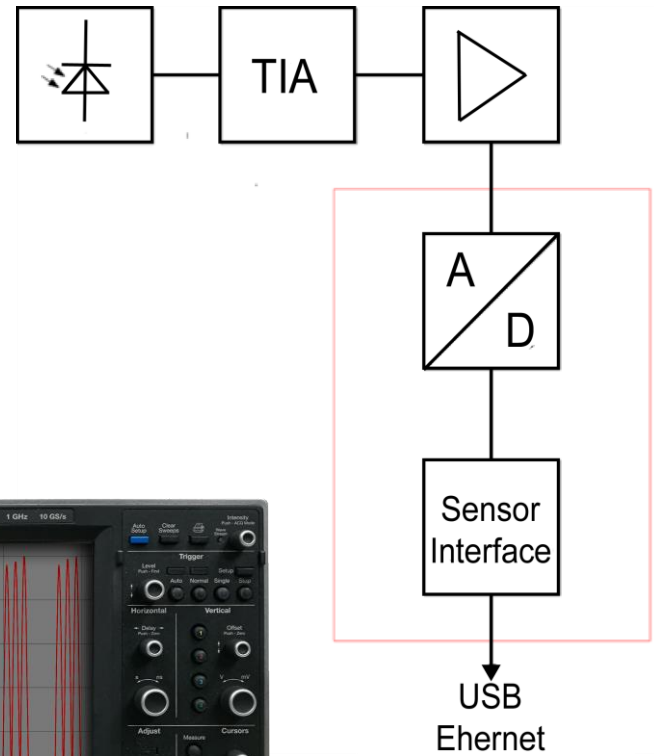
Experimental Setup & Test Method – Flicker Test (2)

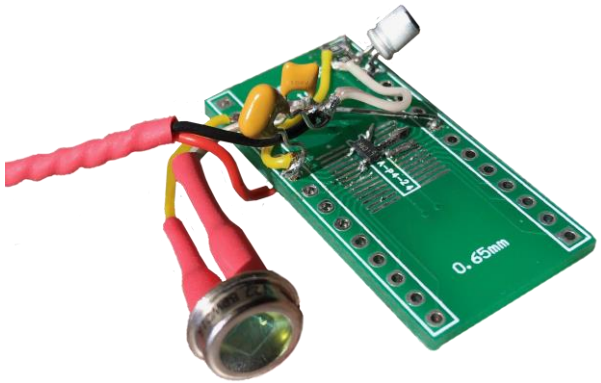
- On test tool developed:
  - Flicker test sequences
  - Sensor hardware
- Flicker test sequences: Alternating black/white frames
  - Uneven frames: white
  - Even frames: black
  - 3840x2160 pixels resolution
- Rendered in 25/30/50/60/90 fps, *ffmpeg*, *libx265* encoder (CRF=0)

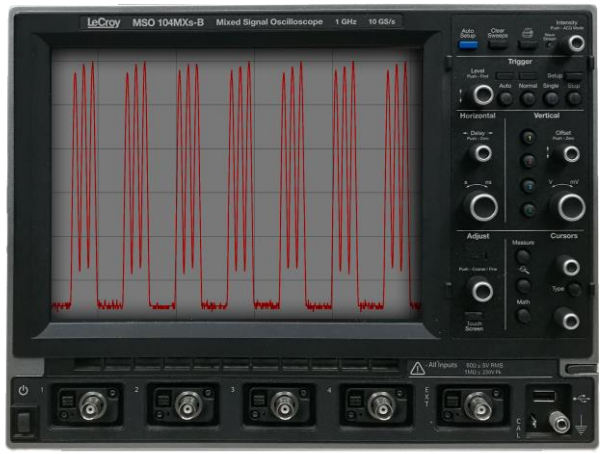


Experimental Setup & Test Method – Flicker Test (3)

- Analog frontend: photodiode, transimpedance amplifier + buffer
- Photodiode's spectral range adapted to human eye
- Connected to Oscilloscope + placed above HMD's display
- Black/White frame changes visible on oscilloscope



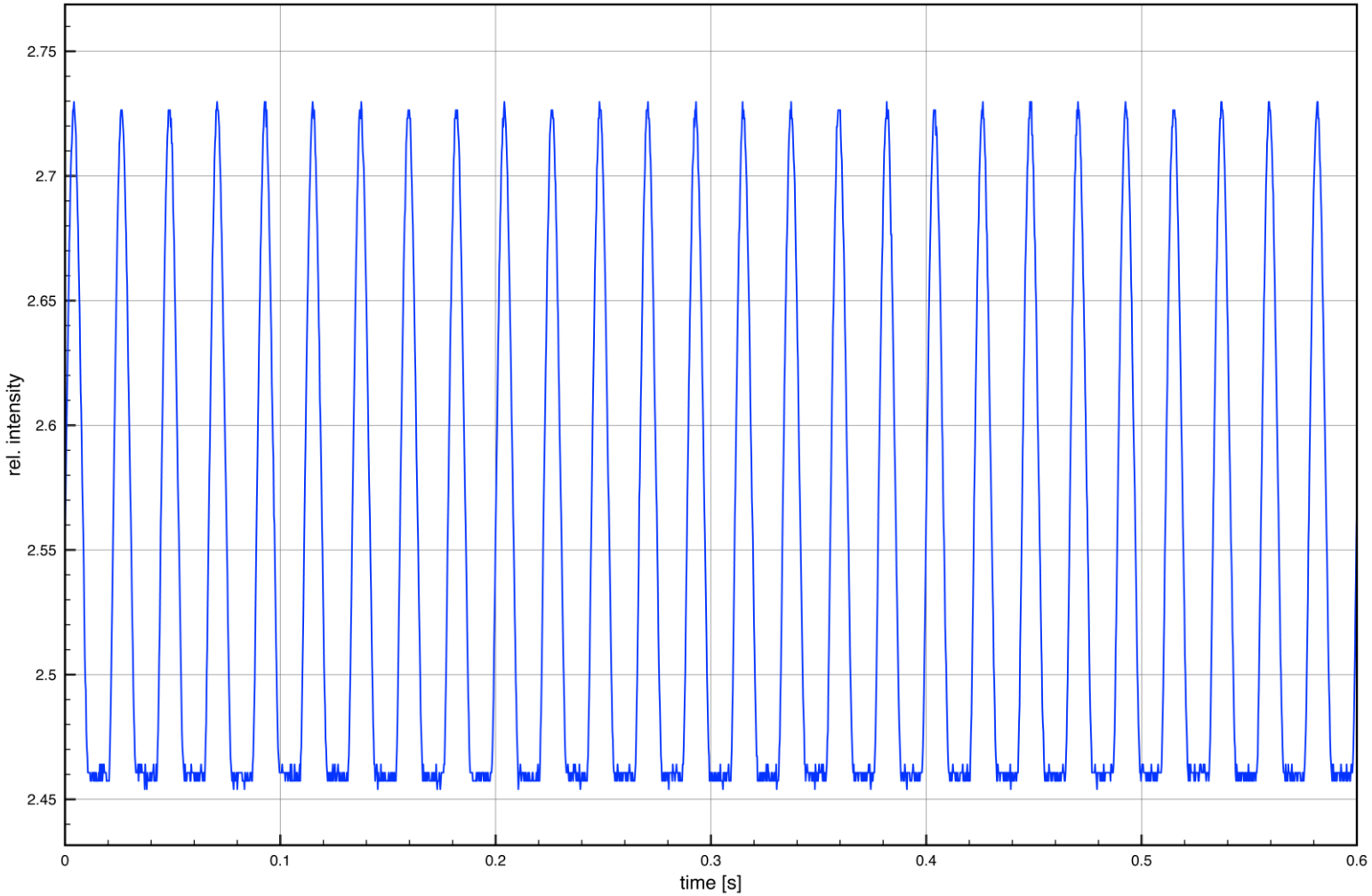




Results Flicker Test (1)

- HMD: HTC VIVE Pro
- Player: Whirligig
- Framerate: 90 fps

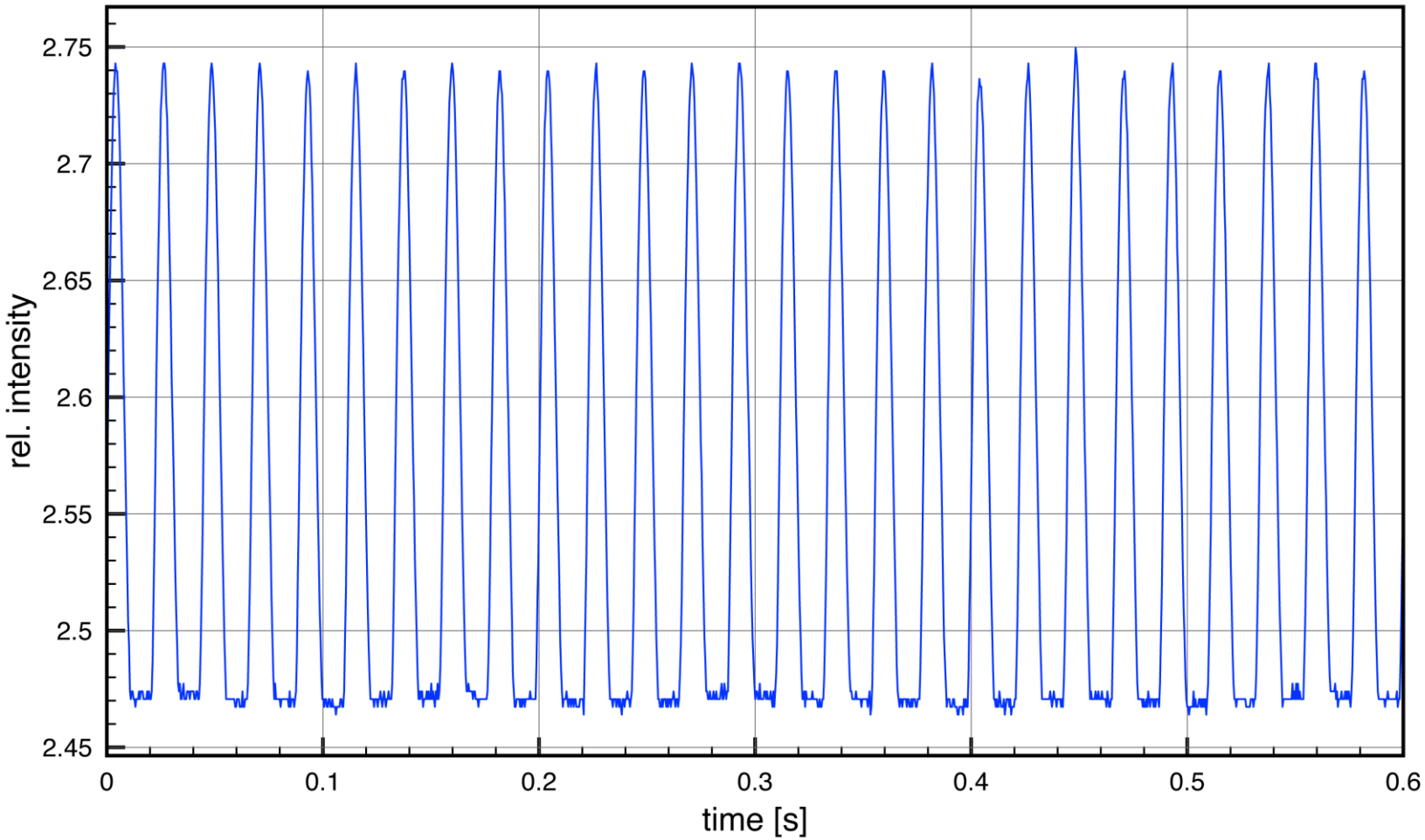
- ✓ No dropped frames
- ✓ Very smooth motion
- ✓ No stuttering
- ✓ No interpolation pattern



Results Flicker Test (2)

- HMD: HTC VIVE Pro
- Player: VD
- Framerate: 90 fps

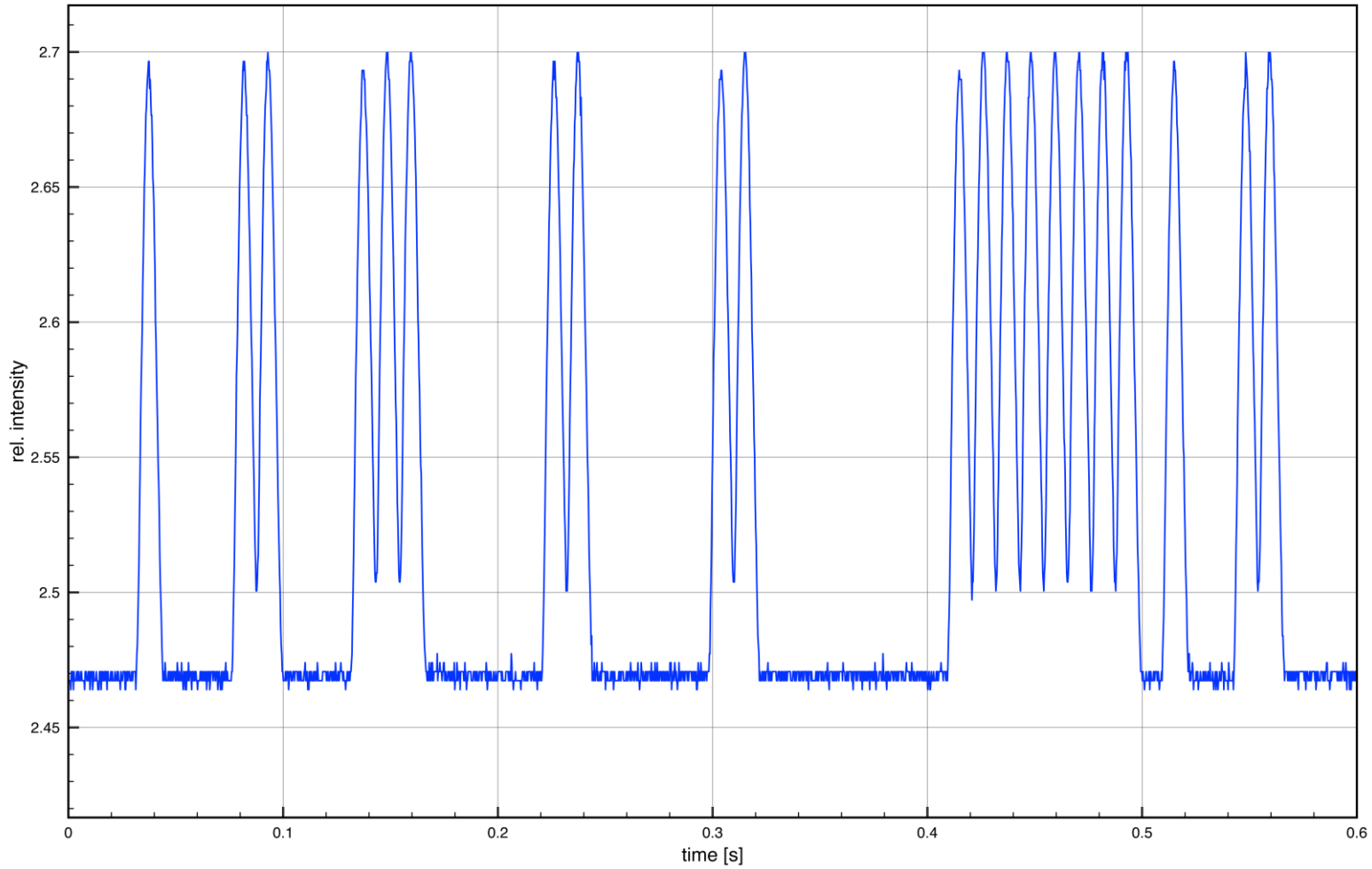
✓ No dropped frames
✓ No interpolation pattern
✓ 25, 30, 50, 90 fps same as Whirligig
✓ Less GPU + CPU power than e.g. Whirligig (almost half)



Results Flicker Test (3)

- HMD: HTC VIVE Pro
- Player: GoPro VR Player
- Framerate: 90 fps

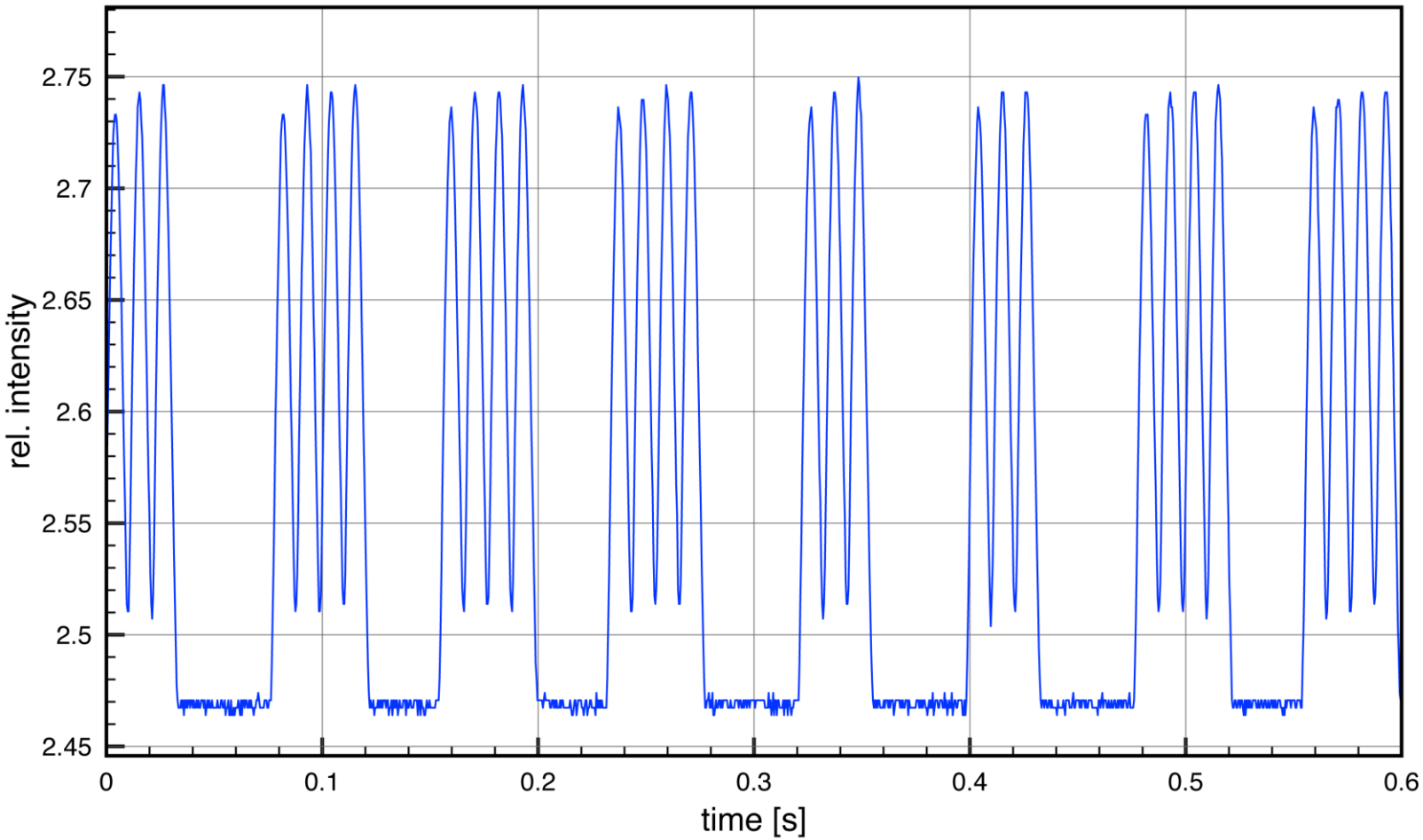
- ❖ Dropped frames
- ❖ Strong stuttering
- ❖ No regular pattern



Results Flicker Test (4)

- HMD: HTC VIVE Pro
- Player: Whirligig
- Framerate: 25 fps

- ❖ No dropped frames
- ❖ Visible stuttering
- ❖ Interpolation pattern recognizable



Results Flicker Test (5)

Summary

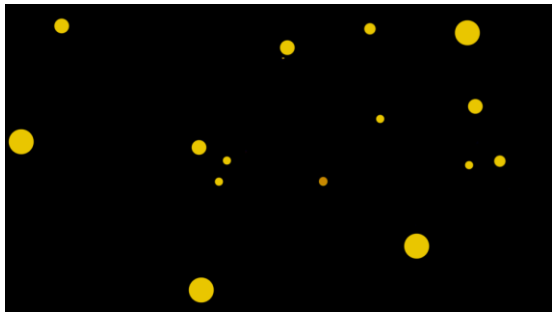
- Recommendations for smooth playout:
  - Use 90 fps 360° content
  - Use Whirligig, Virtual Desktop or another 360° player
  - We avoid usage of GoPro VR Player
  - Avoid playback of 25 fps 360° content

Experimental Setup & Test Method – Subjective Test (1)

- Influence framerate on 360° video quality? → Lack HFR 360° content
- MI for improving QoE?
  - Which MI methods for 360° videos?
- Content selection (20 s)
  - ERP (3820x1920 px.), *ffmpeg* 4.1, *libx265* (CRF=0)
  - Training: 1 CGI content (Moon), 30/90 fps
  - Part I: 1 CGI content (Starfield), 25/30/50/60/90 fps
  - Part II: 4 contents, 30 fps source + 90 fps interpolated (various MI algorithms)
- Wide range of complexity/motion → Mostly "stuttering-affected" videos

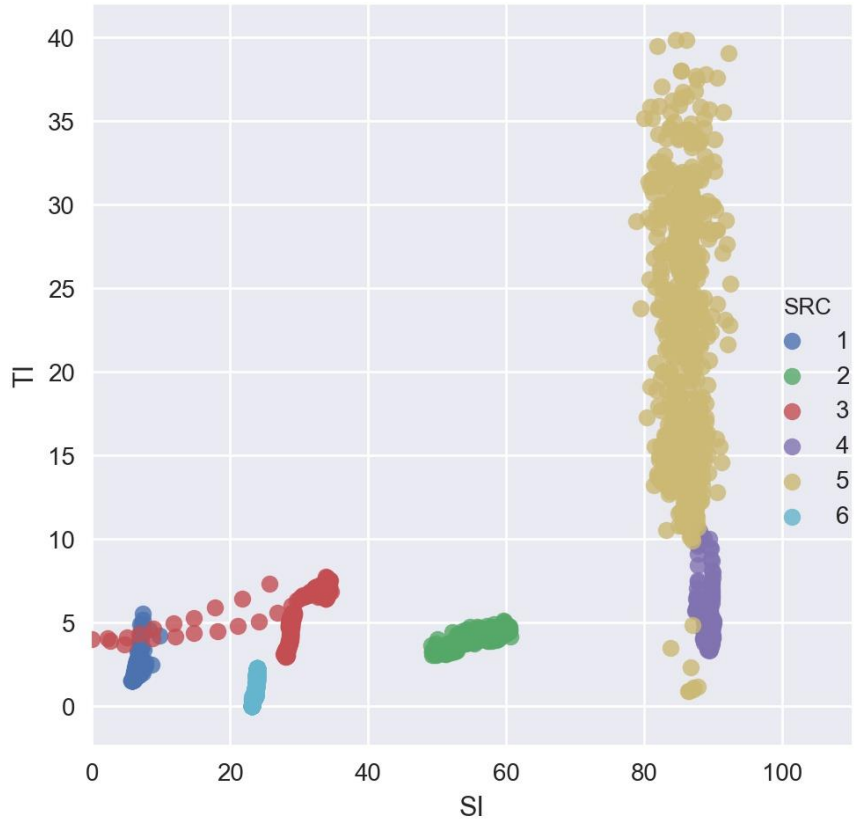
Experimental Setup & Test Method – Subjective Test (2)

CGI contents used



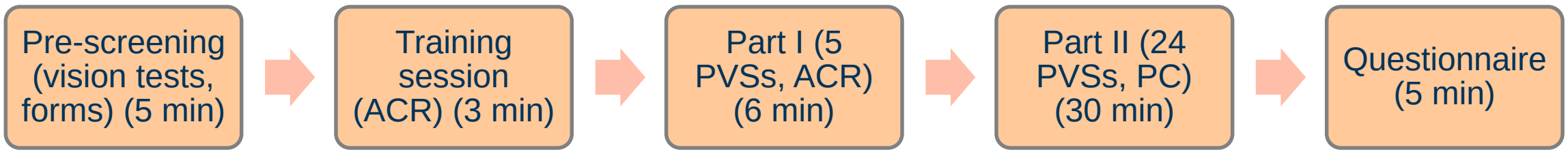
Real contents used

SI/TI values of contents



Experimental Setup & Test Method – Subjective Test (3)

- ACR for training + part I → overall quality
- PC in part II
- MI algorithms part II:
  - *Butterflow* (cf. [But19])
  - *ffmpeg* blend frames
  - *ffmpeg* MCI (Motion Compensated Interpolation)
- Subjective test, 12 video expert viewers, randomized playlists



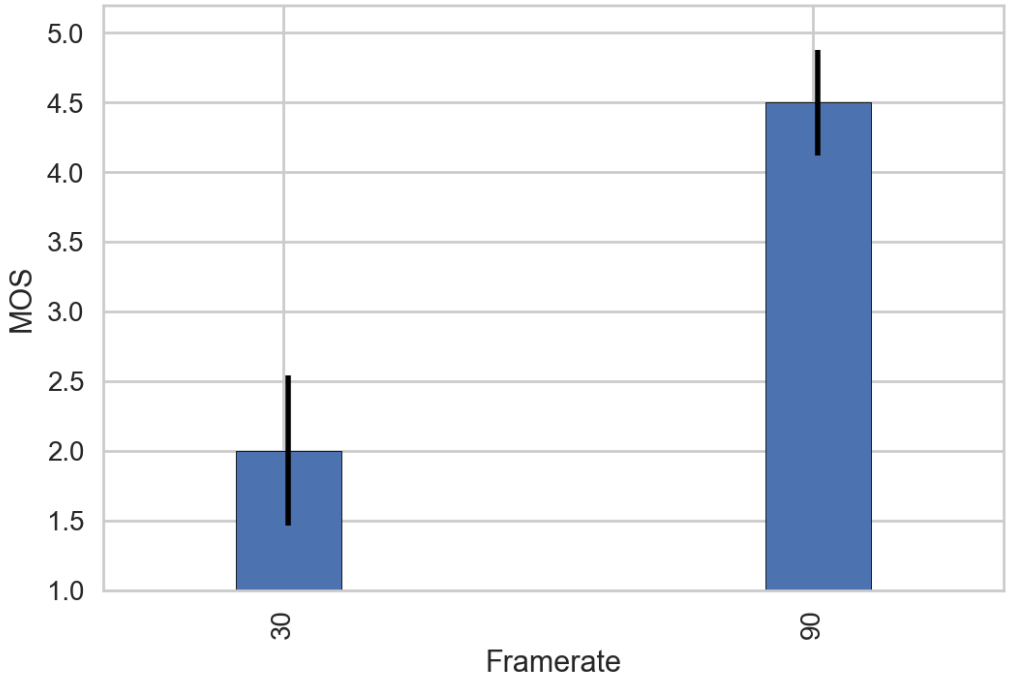
Experimental Setup & Test Method – Subjective Test (4)

- Test method part II: Show participants 2 consecutive videos
- Ask for preferred video
- Answer "equal" also possible
- Source video: 30 fps
- Interpolated video: 90 fps

HRC number	Video 1	Video 2
HRC001	Source (30 fps)	Butterflow (90 fps)
HRC002	Source (30 fps)	Blend (90 fps)
HRC003	Source (30 fps)	MCI (90 fps)

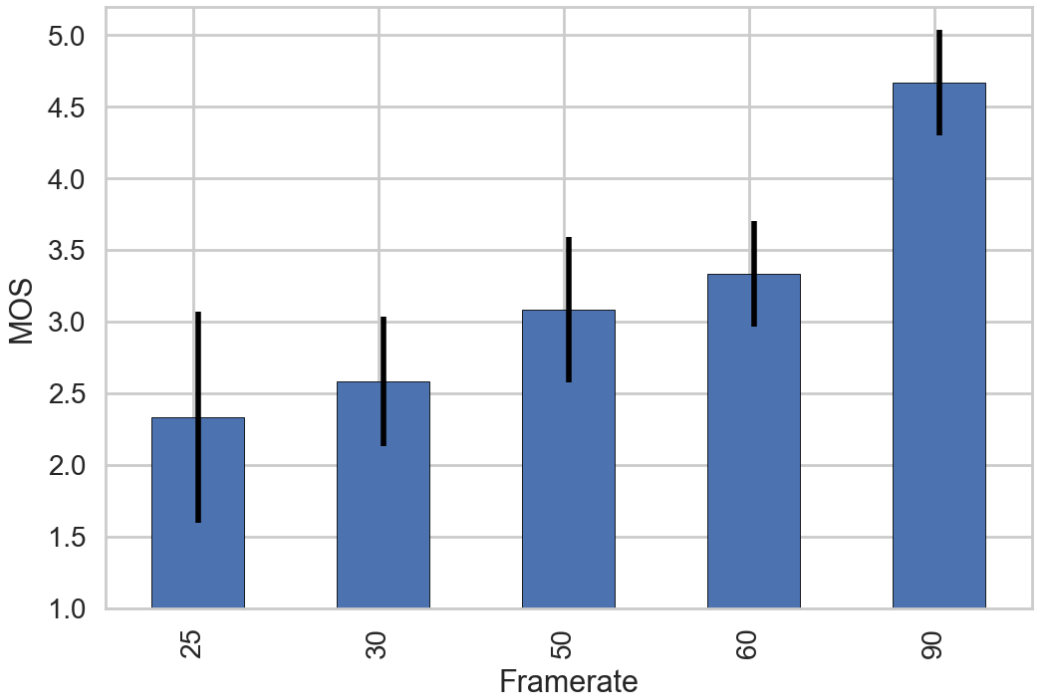
Results Subjective Test – Training

- "Moon" sequence
- Quality difference between 30 + 90 fps clearly visible
- Significant in spite of low number of subjects



Results Subjective Test – Part I

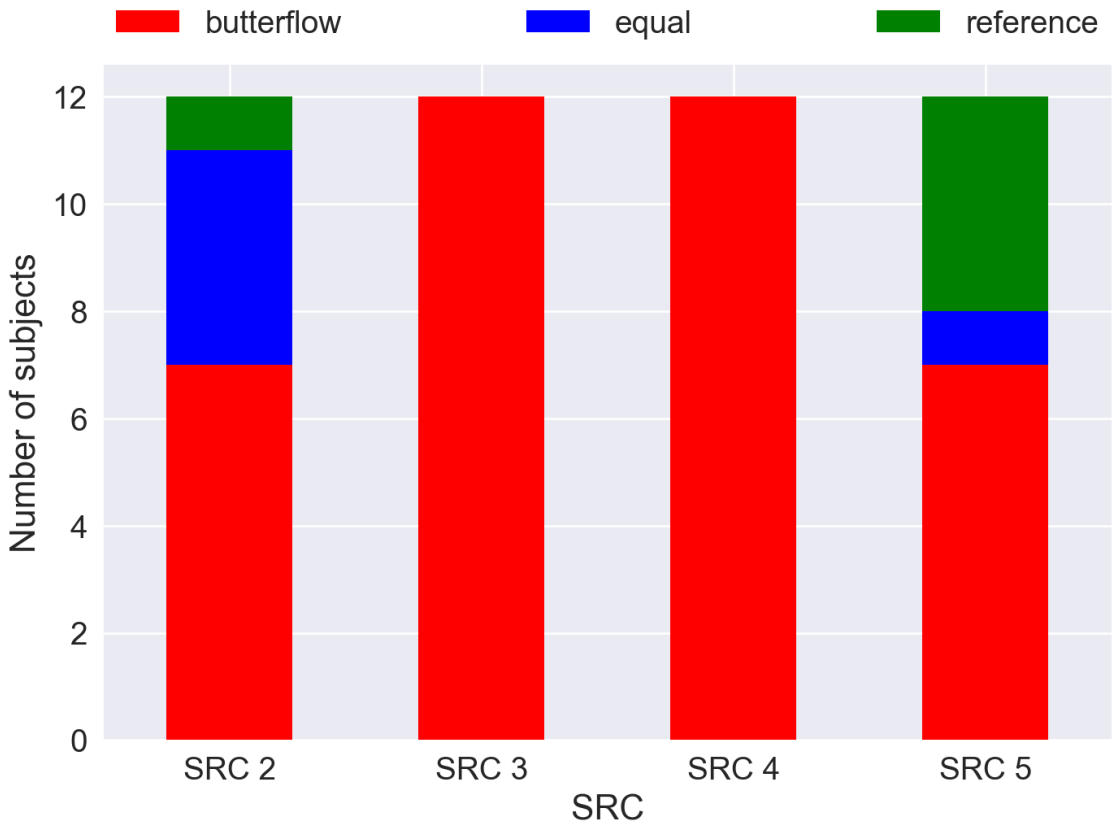
- "Starfield" sequence
- Difference in quality for 25/30/50/60/90 fps clearly visible



Results Preference Subjective Test – Part II (1)

HRC001: Source video vs. Butterflow

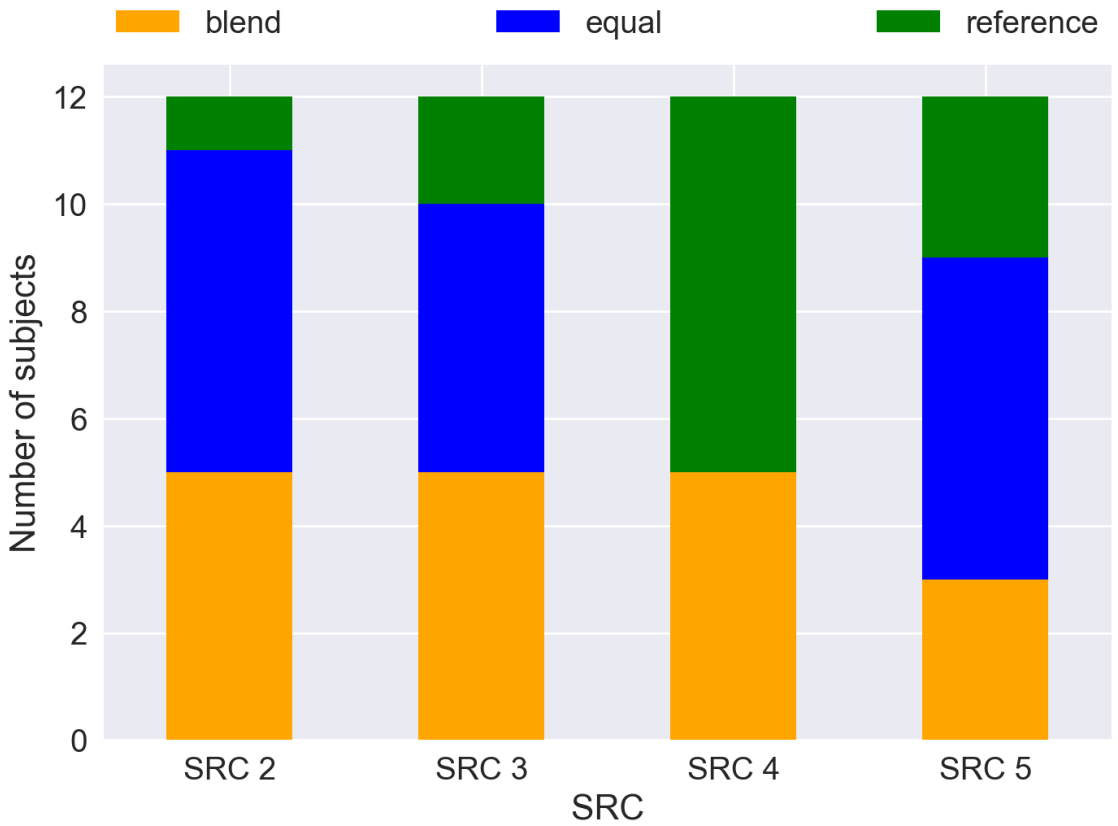
- Butterflow interpolated video always preferred over source video
- SRC 2: Difference not so clearly visible
  → slow motion
- SRC 3 + 4: Clear preference for interpolated video
- SRC 5: Fast + sudden movements in video
  → MI evoking mosquito artifacts
  → Reference video often preferred



Results Preference Subjective Test – Part II (2)

HRC002: Source video vs. Blend

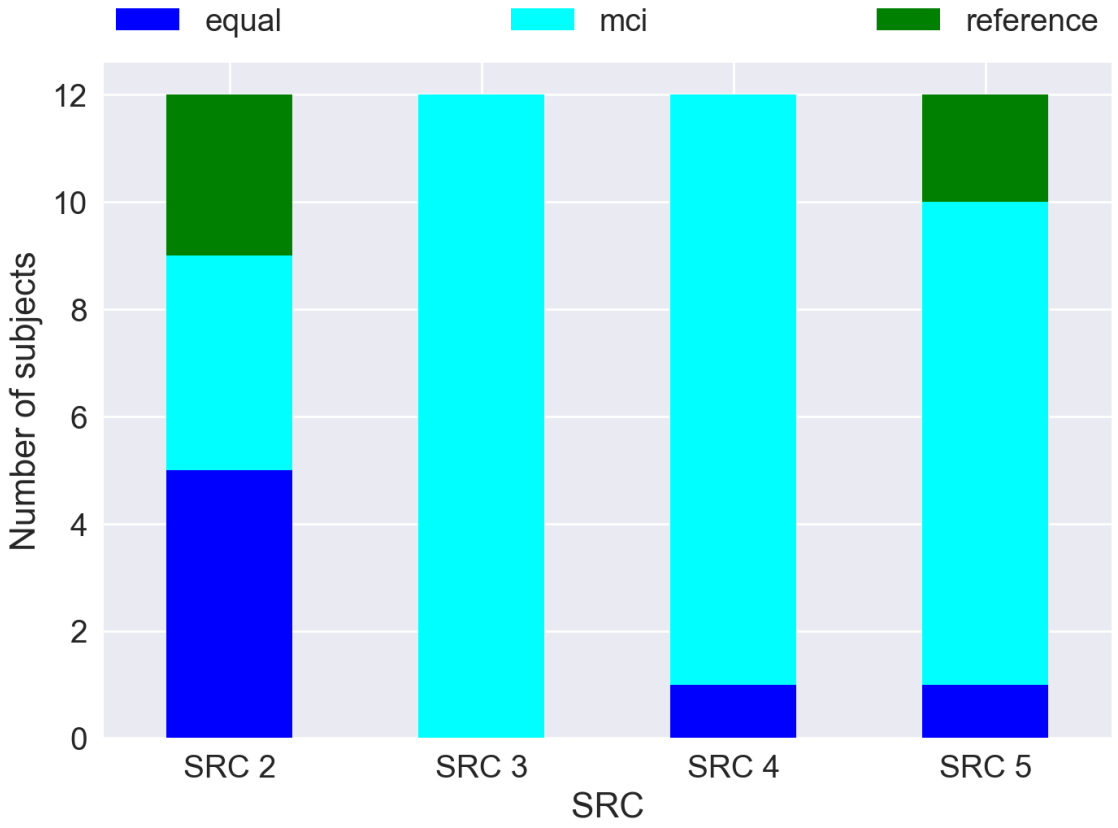
- MI algorithm "Blend" not good results
- Blending leading to blurred images → reference preferred or pair rated as equal
- Interpolation not leading to significant better quality



Results Preference Subjective Test – Part II (3)

HRC003: Source video vs. MCI

- SRC 3-5: Clear preference for interpolated video
- SRC 2: Difference not clearly visible, slow camera movements
- SRC 5: Probably MCI is better suitable for fast movements than butterflow → higher number of preferences



Conclusions

- Different effects of interpolation patterns on playback clearly visible
- General preference of 90 fps over 30 fps content
- Interpolation of 30 fps to 90 fps generally improving quality
- Fast movement: MCI preferred over butterflow
- Medium movement: butterflow slightly preferred over MCI
- ffmpeg "blend" not recommendable
- CGI sequences publicly available

https://github.com/Telecommunication-Telemedia-Assessment/360_testcontent

Questions?

References

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