

Comparing upscaling algorithms from HD to Ultra HD by evaluating preference of experience

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Motivation

- Higher resolution in UHD leads to larger viewing angle
- Upscaling from HD to UHD is required for backwards compatibility
- The added value of pristine UHD content should be quantified in relation to HD content distribution
- What is the best upscaling method from HD to UHD?

Overview

- SRC and HRC setup
- Subjective experiment setup
- Results
 - Bradley-Terry scores
 - Barnard test
- Discussions
- Conclusion

Test setup

- 8 SRC in UHD resolution
- Split into two groups with similar content characteristics
- Downscaled using Lanczos Filter to
 - 1080p (4 SRC Group 1)
 - 720p (4 SRC Group 2)



Test setup

- Upscaling methodologies with low complexity:
 - Bicubic
 - Lanczos-3
 - Lanczos-3 with additional sharpening
- With medium complexity:
 - Catmull-Rom
 - Mitchell-Netravali
- With high complexity:
 - Projection onto Convex Sets (POCS)
 - Robust Super Resolution (RSR)

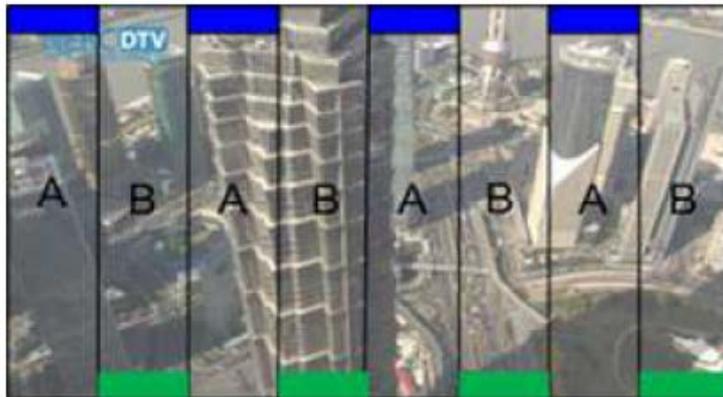
HRC	Up-scaling algorithm	original size	SRC Group1	SRC Group2
1	Reference	-	√	√
2	Bicubic	720p		√
3		1080p	√	
4	Lanczos3	720p	√	√
5		1080p	√	
6	Catmull-Rom	720p		√
7		1080p	√	
8	Mitchell-Netravali	720p		√
9		1080p	√	
10	Lanczos3 +sharpen30	720p		√
11		1080p	√	
12	Pocs	720p		√
13		1080p	√	
14	RSR(Robust Super Resolution)	720p		√
15		1080p	√	√

Test setup

- 7HRC: SRC Group 1 (1080p) was upscaled with all 7 algorithms
 - 1 HRC was added: SRC Group 1 downscaled to 720p and upscaled with Lanczos-3
 - 1 HRC reference UHD
- 7HRC: SRC Group 2 (720p) was upscaled with all 7 algorithms
 - 1 HRC was added: SRC Group 2 downscaled to 1080p and upscaled with Robust Super Resolution
 - 1 HRC UHD

Subjective experiment

- 2 Alternative Forced Choice Paired Comparison setup using Optimal Rectangular Design
- Simultaneous presentation on one screen:



(2 variants AB/BA)

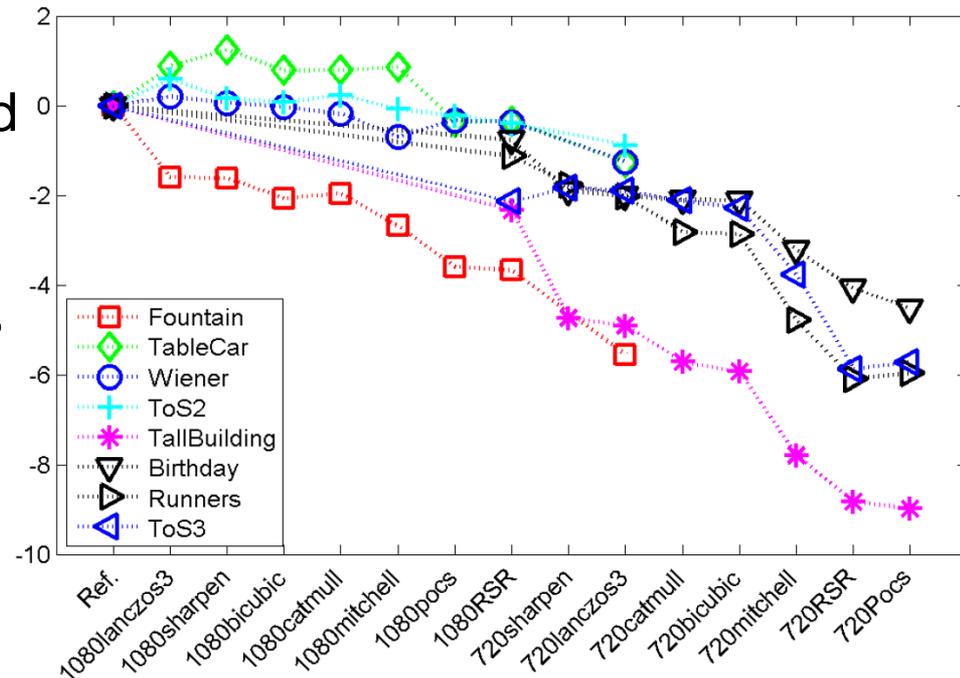


- Small black lines in between stripes
- Slight vertical offset of A and B to visually combine stripes of the same HRC
- Observer chooses blue or green
- 65 inches UHD native consumer grade screen (Panasonic TX-L65WT600E)
- 42 observers (18 male, 24 female), 1H distance (over-critical situation)

Results

■ Bradley-Terry Scores:

- 720p upscaled is consistently worse than 1080p and UHD
- 1080p upscaled may perform better than UHD for example, due to
 - blurring of camera noise
 - high motion content
- Lanczos-3 filtering performed best (with or without sharpening)
- Super-Resolution algorithms may need further parameter tuning



Results

- Barnard test combined over all concerned SRC:
 - No statistical difference is found between the UHD Reference and Bicubic, Lanczos-3, and Catmull-Rom upscaled HD.
 - The upscaling method is more distinctive for 720p than for 1080p

	Ref	1bic	1lanc	1cat	1mit	1shp	1Pocs	1RSR	7bic	7lanc	7cat	7mit	7shp	7Pocs	7RSR
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Discussion concerning visual attention

- UHD provides a larger field of view
 - Similar movements cover twice the visual angle in UHD display environments than in HD (notably when upscaled), potentially reducing visual acuity due to higher retinal velocity
 - Peripheral visual regions are more sensitive to temporal artifacts such as jerkiness
 - Visual attention's center bias may be more pronounced due to the higher effort required on larger screen diagonals (head movement instead of eye movement)

Conclusions

- High quality HD upscaling is feasible with simple algorithms, notably Lanczos-3
- The added value of UHD is easily compromised by insufficient content quality
- More details can be found in:

Li, J., Koudota, Y., Barkowsky, M., Primon, H., & Le Callet, P. (2014).

Comparing Upscaling Algorithms From Hd To Ultra Hd By Evaluating Preference Of Experience.

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