Interactive Subjective Study on Picture-level Just Noticeable Difference of Compressed Stereoscopic Images

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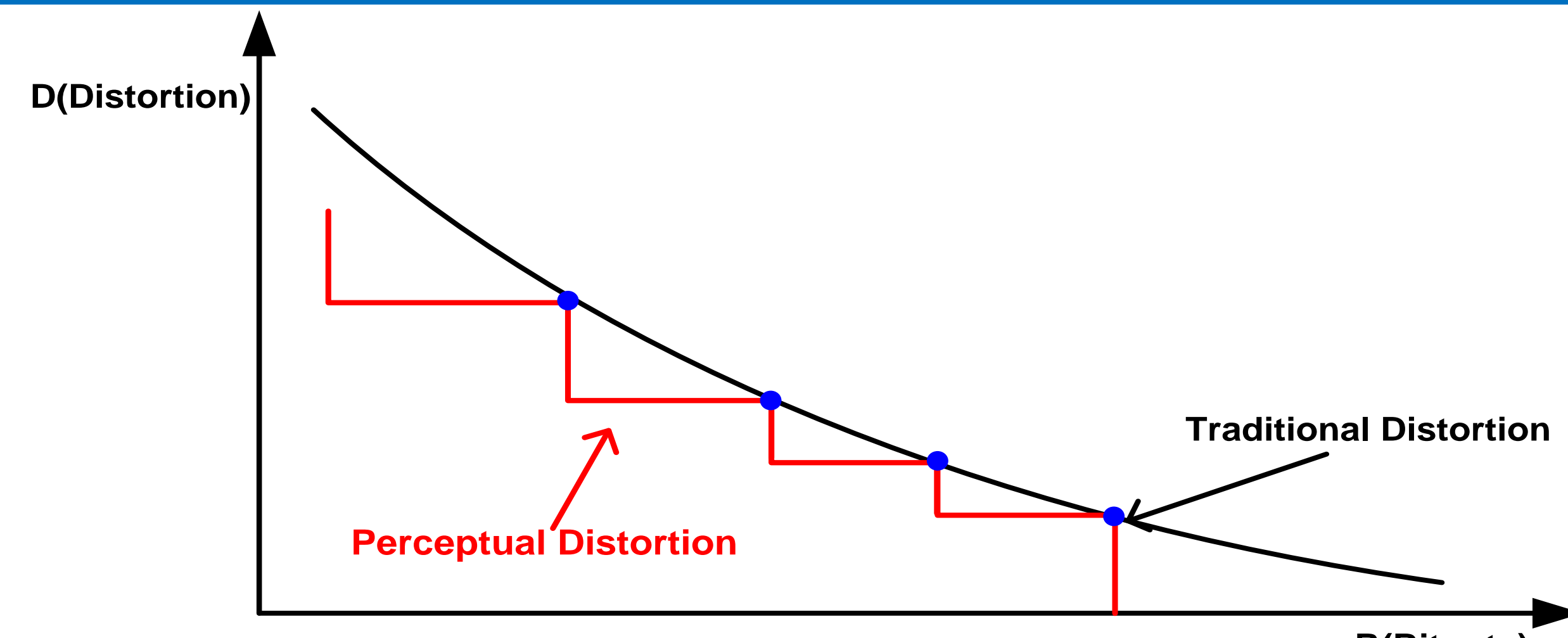
Motivations

Fig. 1 Perceptual and traditional R-D function.

- Perceptual R-D function is piece-wise constant.
- Just Noticeable Difference (JND) reveals the minimum distortion that human visual system can perceive.
- Traditional JND models focus on pixel and sub-band domain. We study the Picture-level JND (PJND) of stereo images.

Proposed Dataset

Fig. 2 Left views of source images in the SIAT-JSSI dataset.

Our dataset includes 10 source stereo images in resolution 1920×1080. The distortion types involved in the test include JPEG2000 and H.265 intra coding.

Table 1 Summarization of the dataset.

Symmetric	Reference Image (L, R)	Comparison Images (L, R)	Number of Distorted Images
1st part	(Source, Source)	H.265:(1, 1),...,(51, 51) JPEG2000:(1, 1),...,(300, 300)	H.265:51×10 JPEG2000:300×10
2nd part	$(\overline{PJND_{PRI}},\overline{PJND_{PRI}})$	H.265:$(\overline{PJND_{PRI}},\overline{PJND_{PRI}})$, ..., (51, 51) JPEG2000:$(\overline{PJND_{PRI}},\overline{PJND_{PRI}})$, ..., (300, 300)	Total:3,510
Asymmetric	Reference Image (L, R)	Comparison Images (L, R)	Number of Distorted Images
1st part	(Source, Source)	H.265:(Source, 1),...,(Source, 51) JPEG2000:(Source, 1),...,(Source, 300)	H.265:51×10×2 JPEG2000:300×10×2
2nd part	$(\overline{PJND_{PRI}},\overline{PJND_{PRI}})$	H.265:$(\overline{PJND_{PRI}}, 1)$, ..., $(\overline{PJND_{PRI}}, 51)$ JPEG2000:$(\overline{PJND_{PRI}}, 1)$, ..., $(\overline{PJND_{PRI}}, 300)$	Total:7,020

Subjective Test

✓ **Subjective test**
- According to ITU-R BT.2022 recommendation.
- Image pairs were shown side by side on a 65' 3D monitor with native resolution 3840×2160.

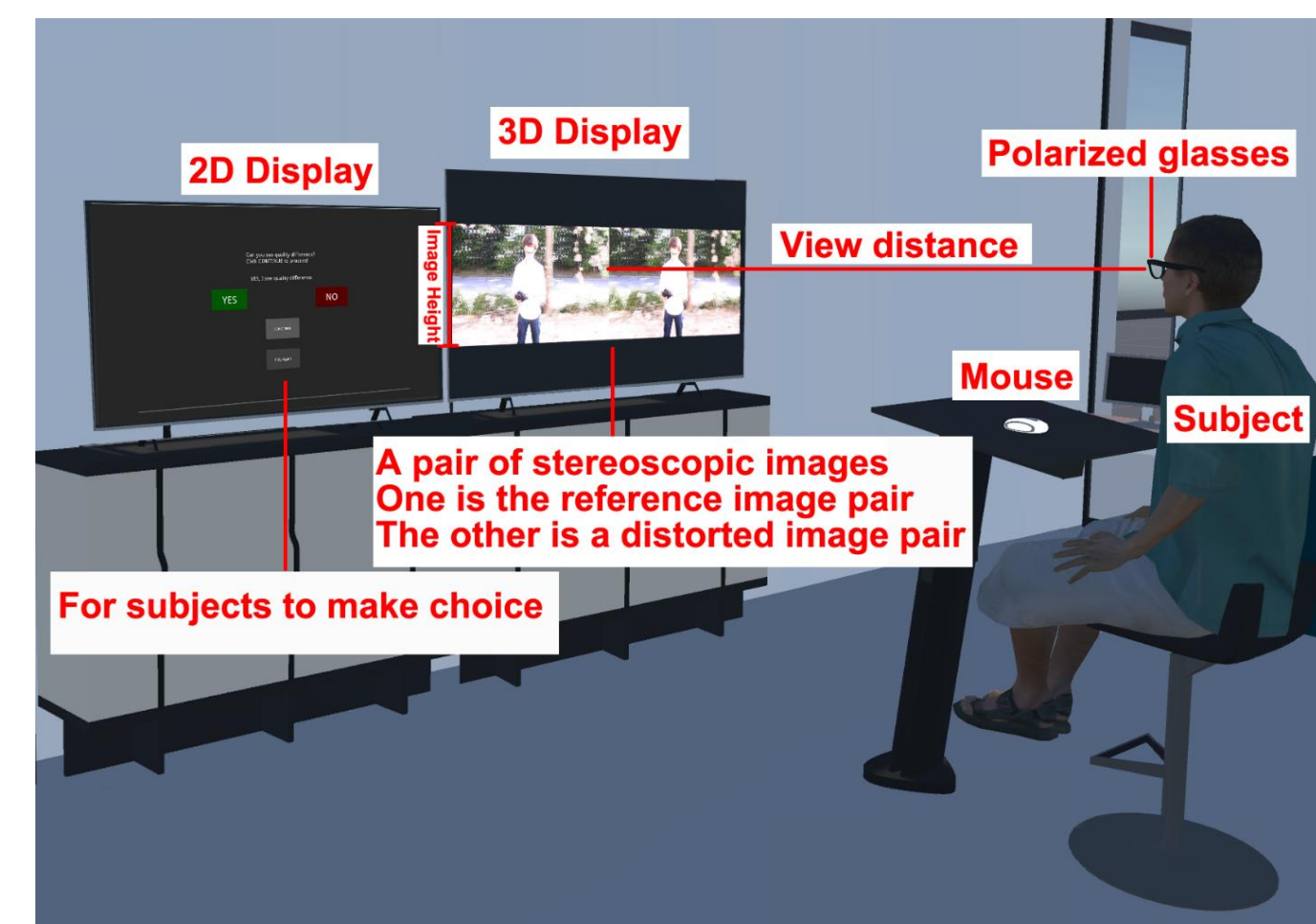✓ **Post-processing**
The outliers are detected and removed.

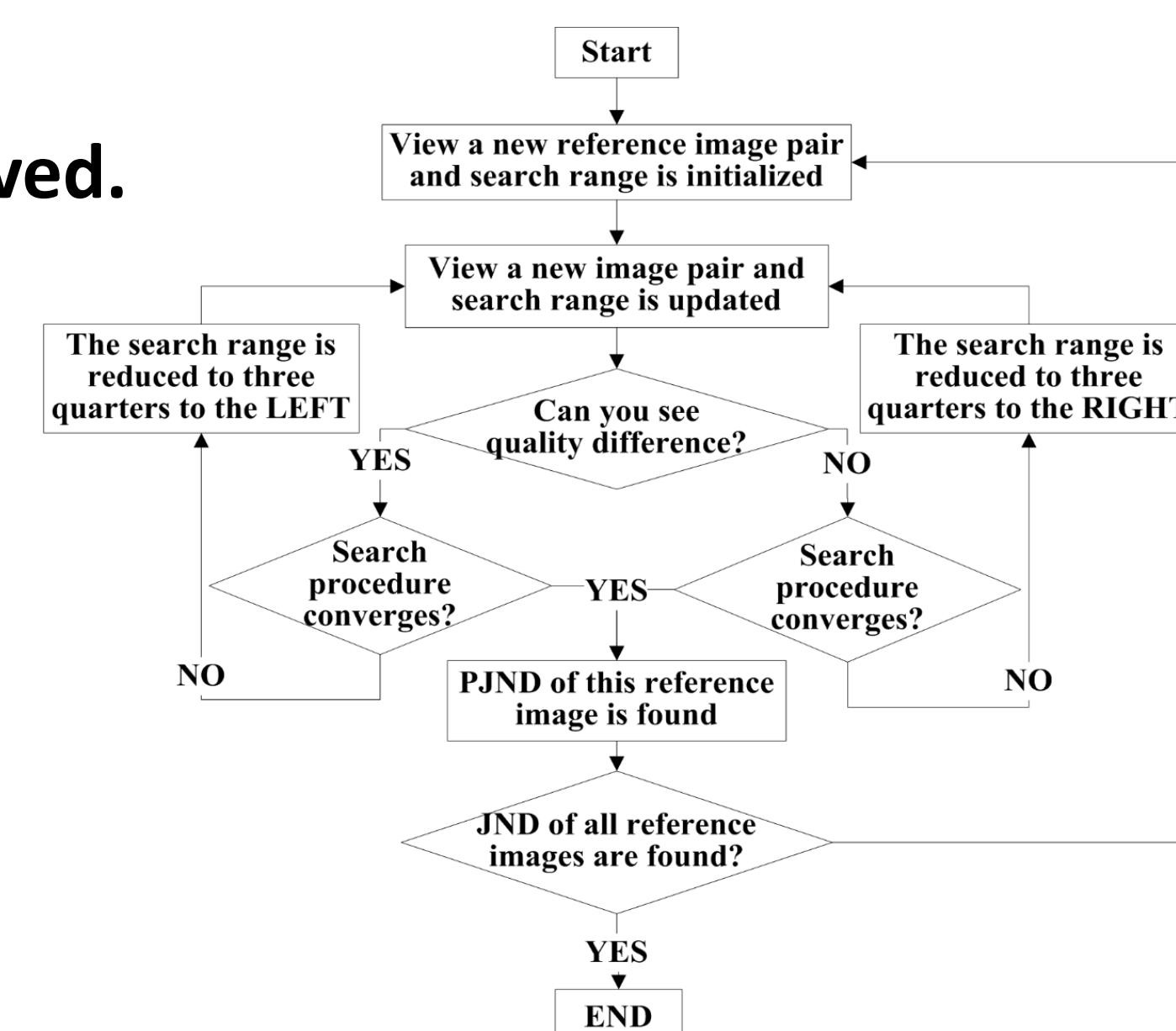Fig. 3 Subjective test environment.
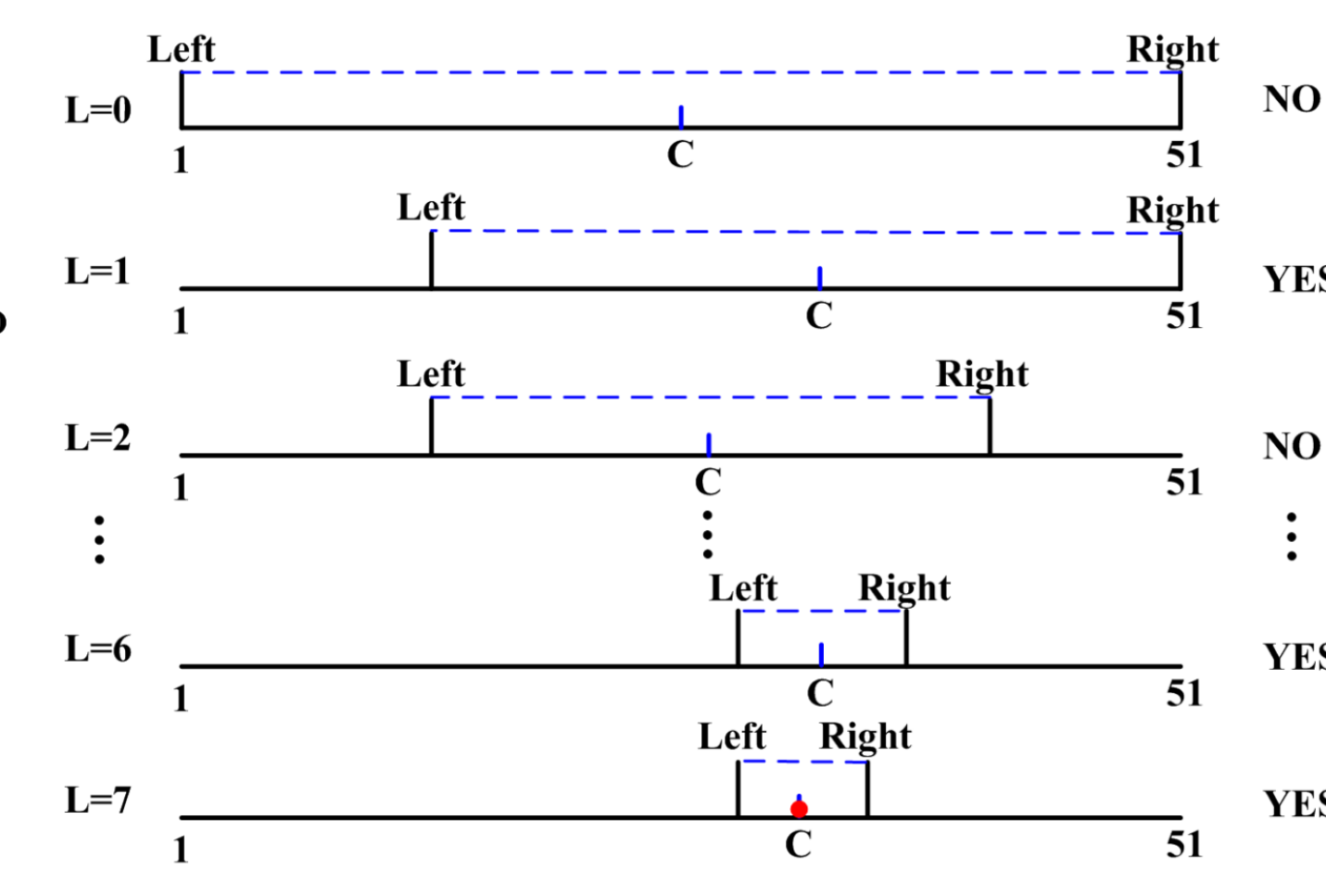

Fig. 4 Flowchart of the procedure.

Fig. 5 An example of the procedure.

Analyses and Discussions

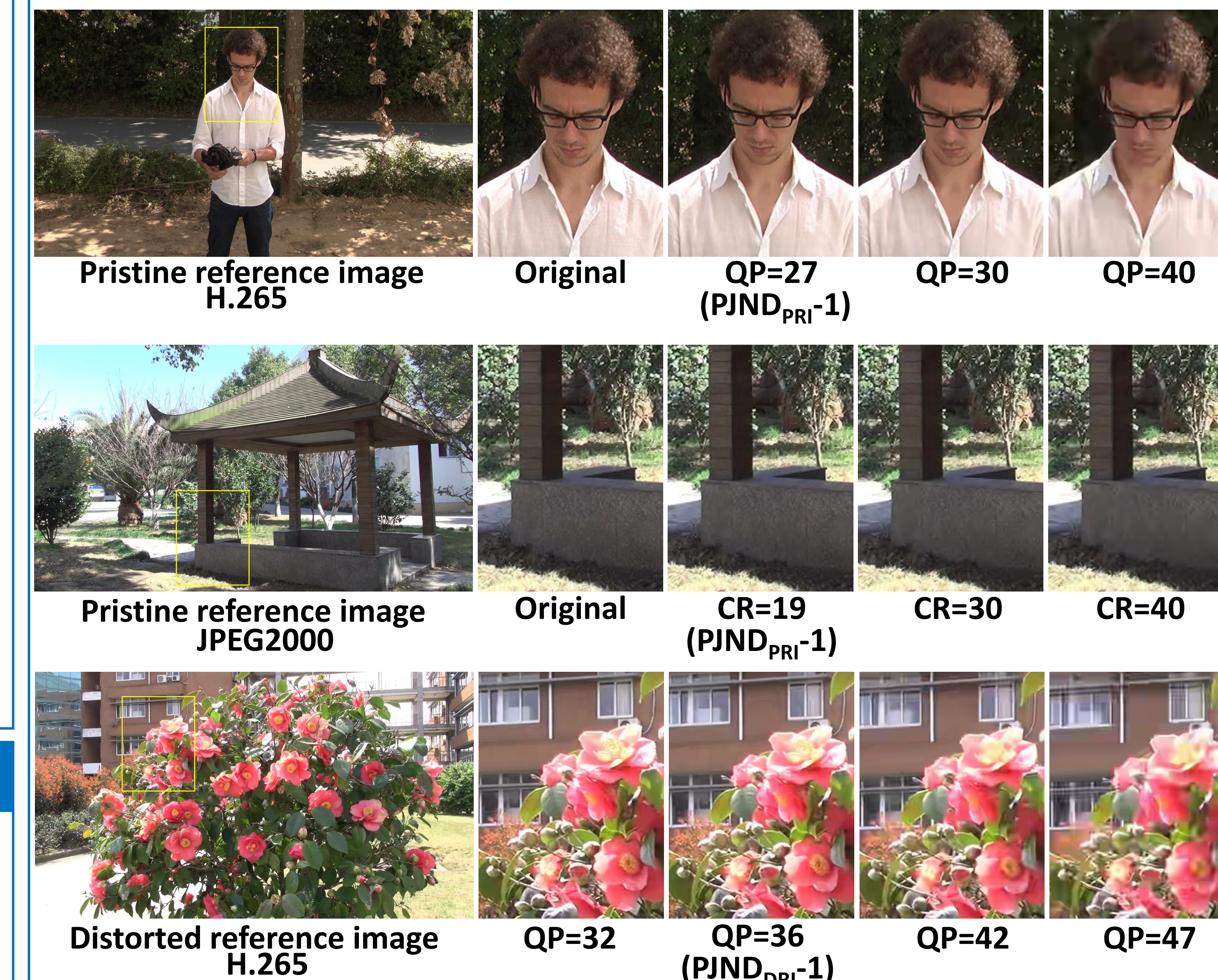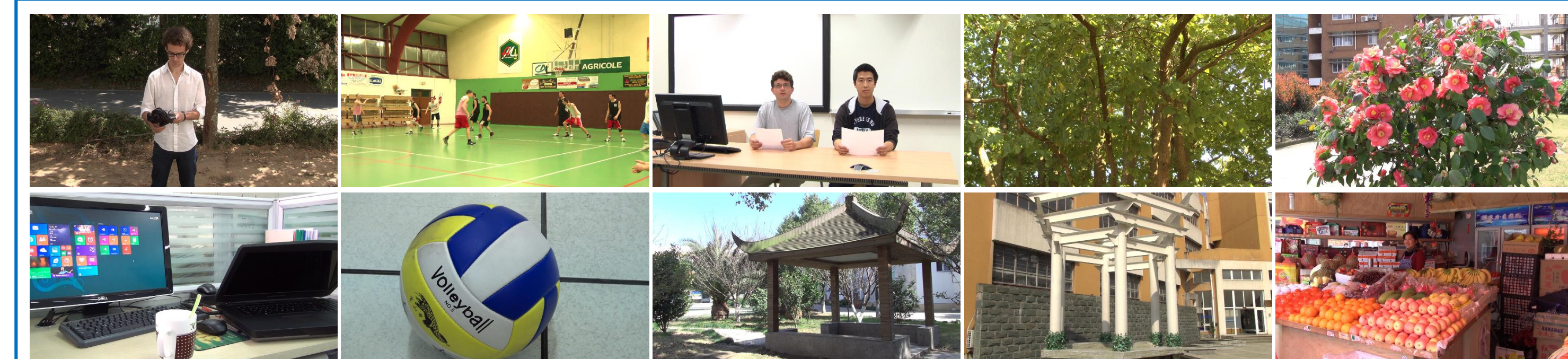The Satisfied User Ratio (SUR) S_n for a distorted image d_n of a source image is

$$S_n = 1 - \frac{1}{M}\sum_{m=1}^{M}\Phi_m(d_n)$$

where M is the number of subjects. if subject m can perceive a quality difference, $\Phi_m(d_n)=1$; otherwise, $\Phi_m(d_n)=0$.

PJND is defined as the 75% of the SUR.
- The SUR decreases as the distortion increases.
- The real collected data fits well the normal distribution.
- The PJND points vary with the image contents.

Table 2 PJND for H.265 and JPEG2000 compression in SIAT-JSSI.

Image	H.265				JPEG2000			
	$PJND_{PRI}$		$PJND_{DRI}$		$PJND_{PRI}$		$PJND_{DRI}$	
	QP	PSNR(L/R)	QP	PSNR(L/R)	CR	PSNR(L/R)	CR	PSNR(L/R)
People	28	35.48/35.46	36	30.86/30.87	54	28.46/28.56	148	27.96/28.10
Basketball	28	40.37/40.28	37	35.34/35.17	114	33.66/33.28	180	31.41/31.17
NewsReport	33	38.78/38.60	35	37.96/37.74	156	38.45/37.96	193	36.78/36.42
Treebranches	27	36.20/36.21	36	30.51/30.50	27	26.25/26.27	137	25.31/25.52
Flower	33	33.84/34.76	37	31.21/31.24	45	26.77/28.62	145	26.11/27.84
Computer	28	39.64/40.80	35	35.72/36.72	123	34.60/36.35	174	33.25/34.86
Volleyball	30	38.93/38.34	36	36.43/35.06	170	37.78/35.83	201	36.89/35.28
Pavilion	26	37.89/38.10	34	31.91/30.09	29	25.64/26.25	143	25.34/25.97
Building	30	38.11/38.69	35	35.14/35.70	78	33.43/34.39	150	32.81/33.80
FruitStore	25	40.32/40.66	35	34.38/34.70	56	32.27/32.89	146	31.30/31.84

(a) JPEG2000.
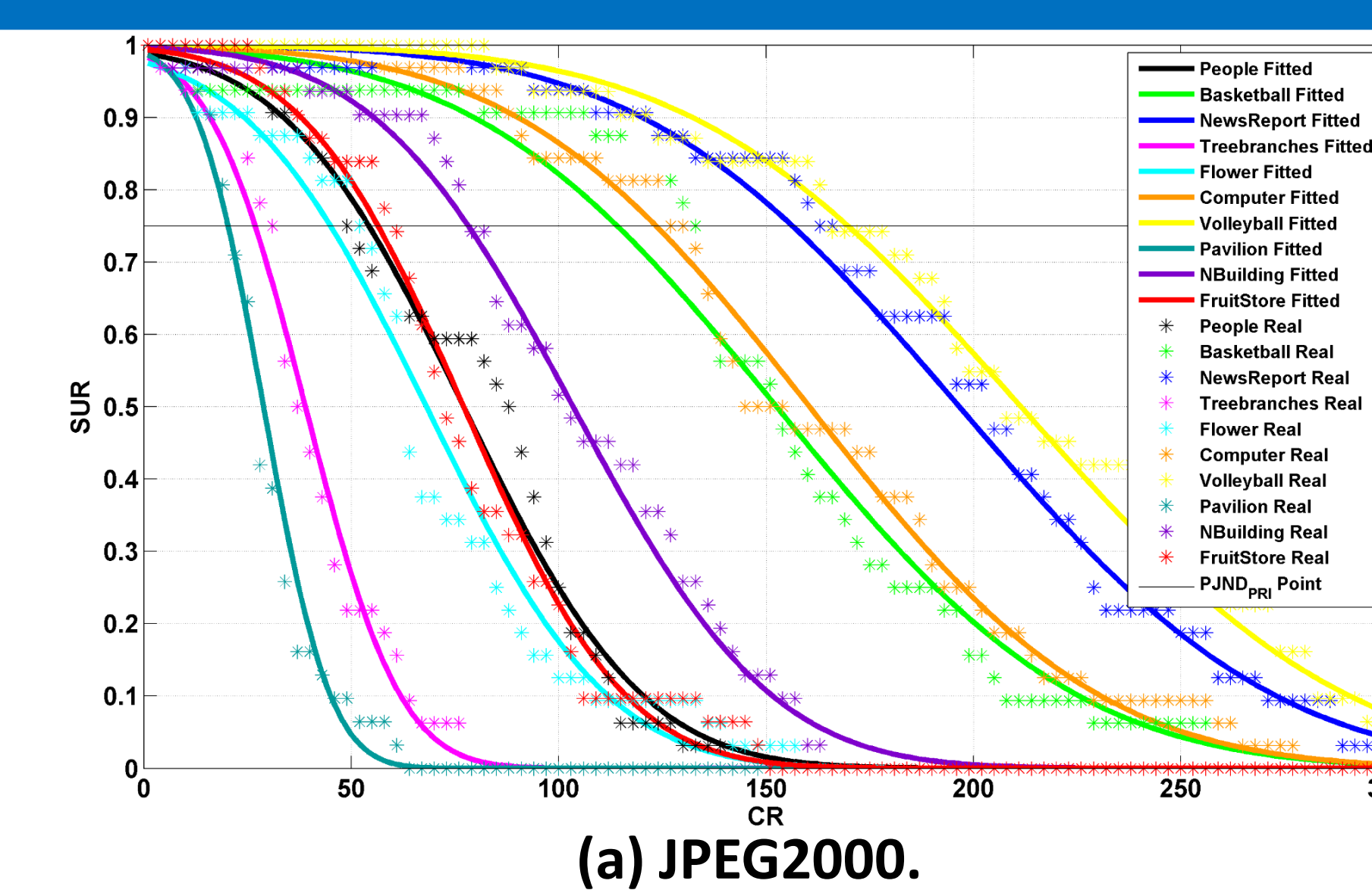
(b) H.265 intra coding.
Fig. 6 SUR curves and real collected data.

Reference images and their distorted versions

Pristine reference image H.265 · Original · QP=27 ($PJND_{PRI}$-1) · QP=30 · QP=40

Pristine reference image JPEG2000 · Original · CR=19 ($PJND_{PRI}$-1) · CR=30 · CR=40

Distorted reference image H.265 · QP=32 · QP=36 ($PJND_{DRI}$-1) · QP=42 · QP=47

Fig. 7 Reference images and their distorted versions.

Conclusions

✓ Present subjective test to study the PJND of stereo images.

✓ Explore the $PJND_{PRI}$ and $PJND_{DRI}$.
- $PJND_{PRI}$: against a pristine reference image (PRI).
- $PJND_{DRI}$: against a distorted reference image (DRI).

✓ Release PJND-based stereo image datasets, which we made available to the public for further research.
Download website: http://codec.siat.ac.cn/SIAT-PJND-index.html

Our findings can be used in perception-based coding and processing.