

IECにおける動画ボヤケ評価について

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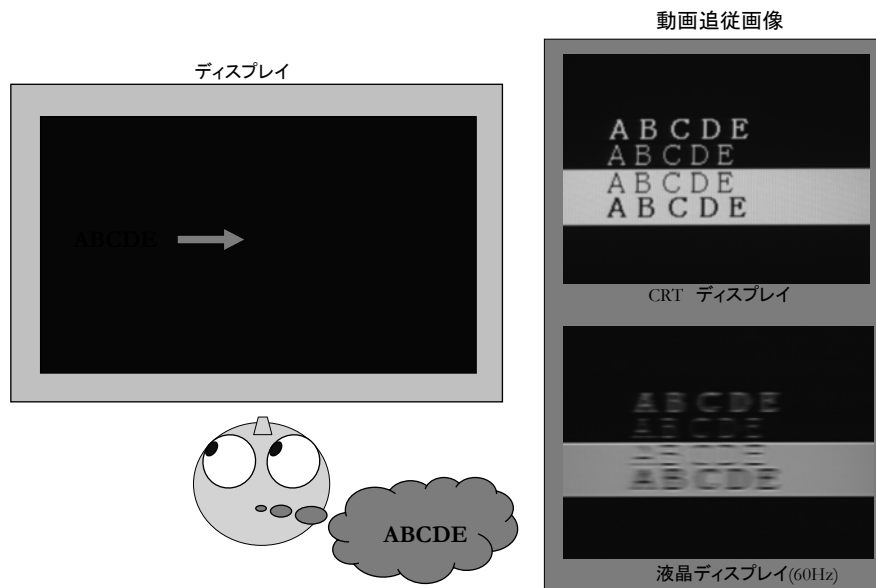
Contents

- 動画ボヤケとは
- IEC Motion Artifact Measurement について
 - Test pattern
 - Measurement method
 - Analysis method
- 各測定方法における動画ボヤケの評価例
- 3Dディスプレイにおける動画ボヤケの評価の紹介
- まとめ

動画ボヤケとは



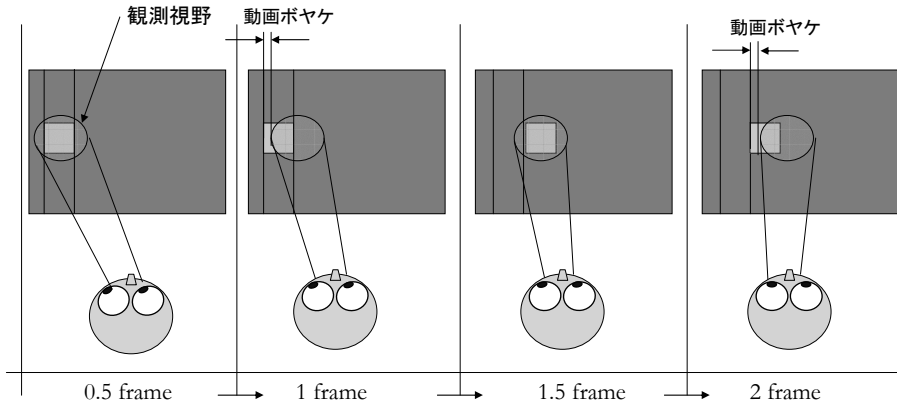
動画ボヤケとは



眼球を動画の速度に合わせてスムーズに移動させて動画を認識する。



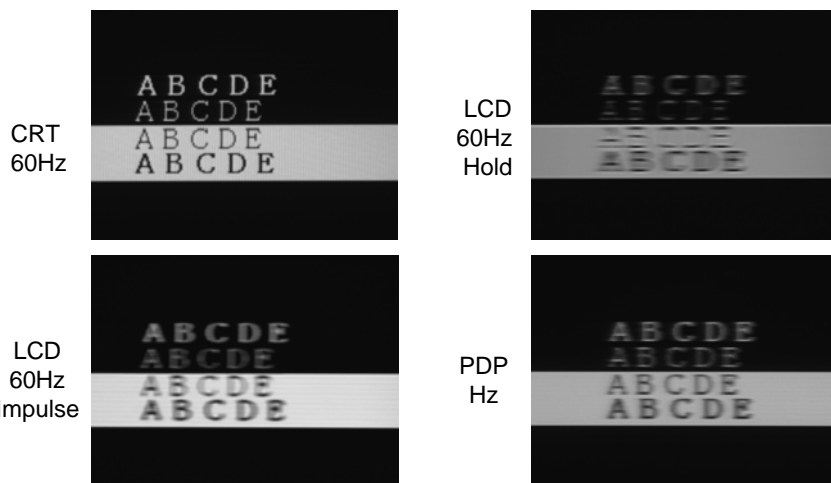
動画ボヤケの発生原因



- 動画ボヤケはディスプレイ上の画像が止まっている(ディスプレイの表示周期)にもかかわらず眼球を移動させるために発生する。
- 動画ボヤケ時間はディスプレイの表示位置が保持されている時間となる。



動画追従画像



Scroll speed 8 pixel/frame, Video signal 720p (for TV-set) or XGA (for PC monitor)



動画追従画像

CRT
60Hz



LCD
60Hz
Hold



LCD
60Hz
Impulse



PDP
Hz



Scroll speed 8 pixel/frame, Video signal 720p (for TV-set) or XGA (for PC monitor)



IEC TC-110 Part 6-3: Motion Artifact Measurement of Active Matrix Liquid Crystal Display Modules



Part 6-3: Motion Artifact Measurement of Active Matrix Liquid Crystal Display Modules

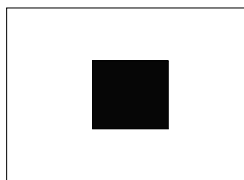
- Test pattern
 - Full Test Pattern
 - Box Test Pattern
 - Line bar Test Pattern
- Standard motion-blur measurement
 - direct measurement method
 - Pursuit measurement system
 - Indirect measurement method
 - Temporal step response
 - High speed camera
- Analysis method
 - Blur edge time
 - Extended blur edge time
 - Perceived blur edge time



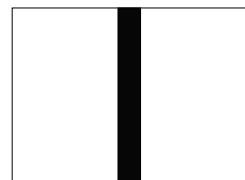
Test patterns



Full Test Pattern



Box Test Pattern

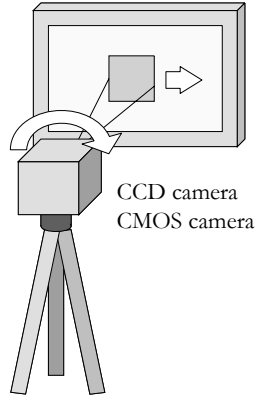


Line Test Pattern



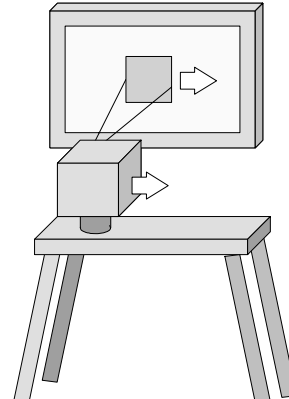
Direct measurement method Pursuit detection system

Pivoting pursuit camera system



カメラ回転追従方式

Linear pursuit camera system



カメラ直線追従方式



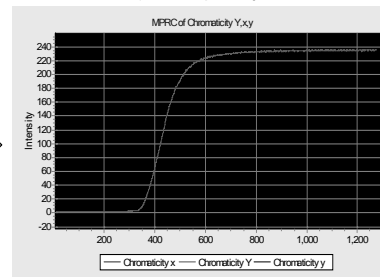
Pursuit detection system Motion picture response curve

動画追従画像



Captured image by the pursuit detection system

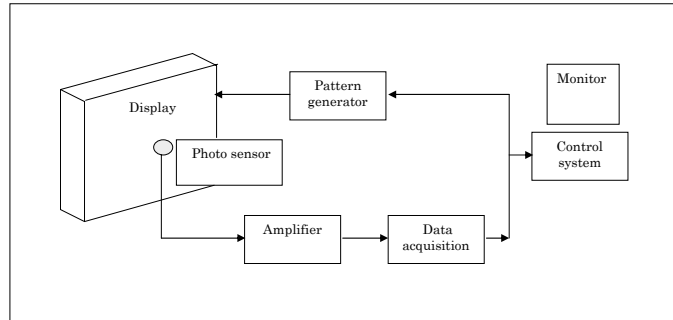
動画応答曲線



Motion picture response curve



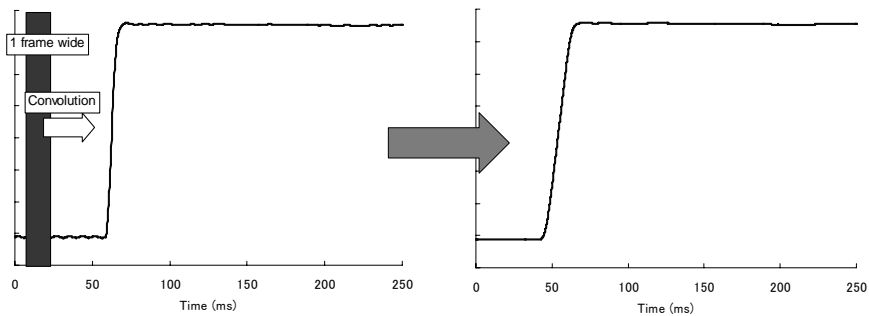
Indirect measurement method Temporal step response



応答測定システム(レスポンス測定システム)



Temporal step response Motion picture response curve



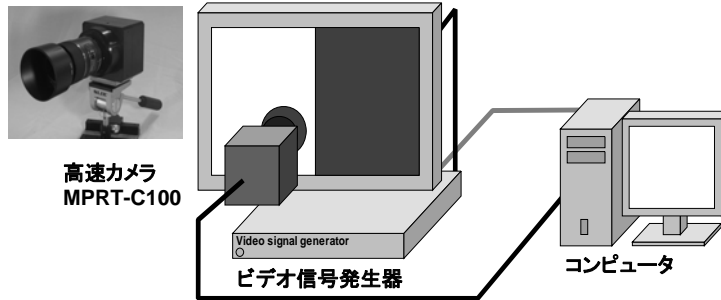
LC response time measurement

Motion picture response curve

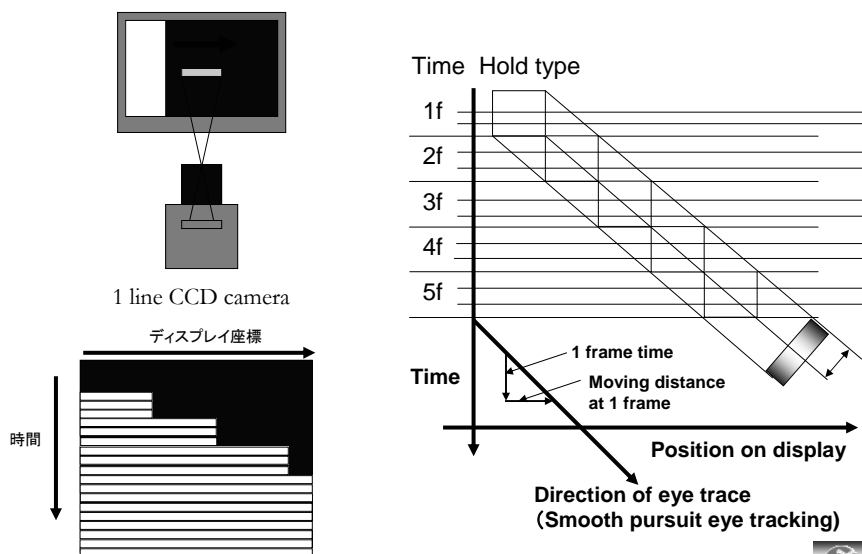
simple convolution of the step response with a moving window function of 1-frame time wide



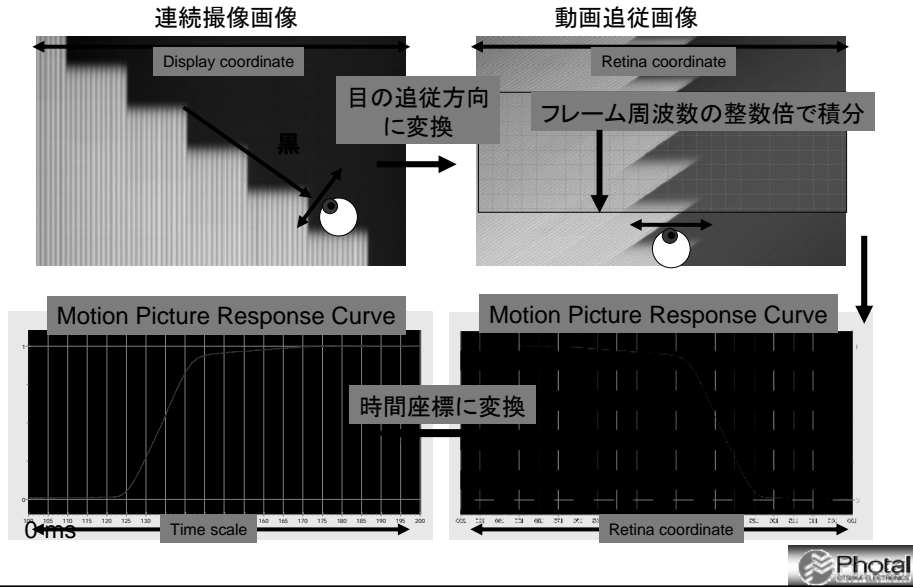
Indirect measurement method High speed camera



Indirect measurement method High speed camera

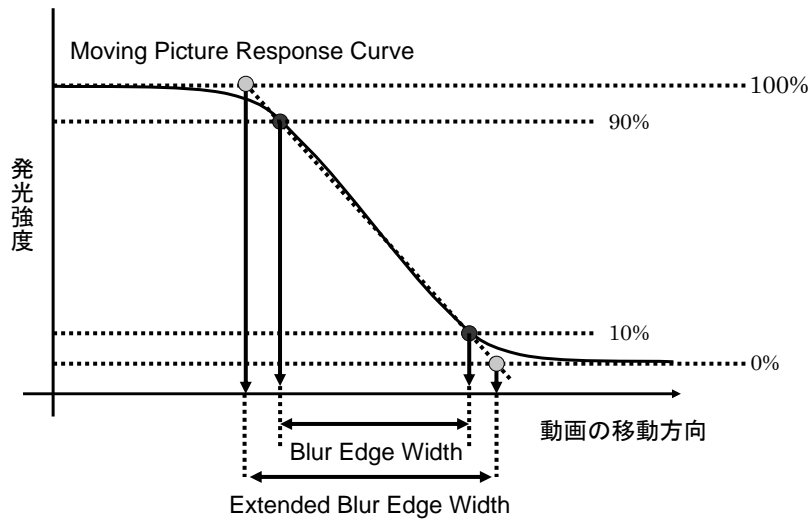


動画応答曲線の算出方法



Analysis method

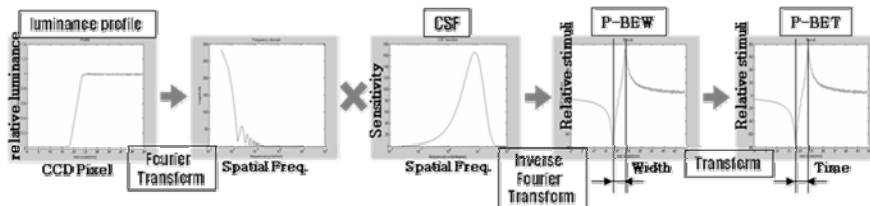
Blur Edge Time and Extended Blur Edge Time



- BET : Other ranges, such as 40% to 60%, can be used, but they shall be reported.
- EBET : The extended blurred edge time is defined as $EBET = BET/0.8$, which linearly extends the BET to the 0% to 100% levels.



Perceived blur edge width and time



Barten's CSF formulae

$$S(u) = \frac{M_{opt}(u)/k}{\sqrt{T \left[\frac{1}{X_0^2} + \frac{1}{X_{max}^2} + \frac{u^2}{N_{max}^2} \right] \left[\frac{1}{\eta p E} + \frac{\Phi_0}{[H_1(w)\{1 - H_2(w)F(u)\}]^2} \right]}}$$

- $S(u)$: spatial contrast sensitivity function for binocular vision
- $m(u)$: modulation threshold
- u : spatial frequency
- σ : standard deviation of the line-spread function of the eye
- k : signal-to-noise ratio (3.0)
- T : integration time of the eye (0.1 sec)
- X_0 : angular size of the object
- X_{max} : maximum angular filed size of the object (12°)
- N_{max} : maximum number of cycles over which the eye can integrate (15 cycles)
- η : quantum efficiency of the eye (0.03)
- p : photon conversion factor, depending on the light source

For the calculations, the viewing distance is set to 1.5 times the diagonal screen size of the active display area

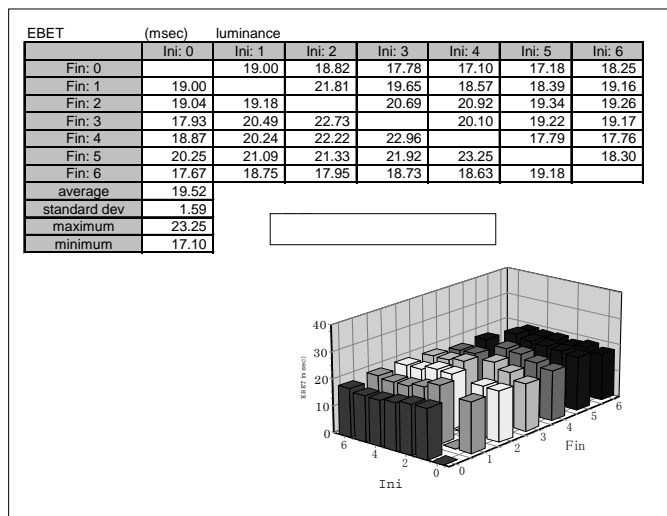


Report

- Environmental condition
 - Temperature, humidity, and atmospheric pressure
 - Illumination level
 - Other conditions which are different from the measuring conditions
- Display parameters
 - Refresh rate
 - Native display resolution
 - Backlight driving (impulse, stationary, blinking, scanning, other)
 - Minimum and peak luminance
 - Display gamma function (sometimes referred to as electro-optical transfer function).
 - Display settings (if applicable)
 - Drive mode (when optional driving mode, e.g. "over drive" are installed in the module, the driving mode used for the test shall be reported)
- Measuring method and conditions
 - Measuring device (pursuit detection system, temporal step response, high speed camera)
 - Number of bits in the measuring device, used to capture the luminance signal
 - For imaging devices, the number of CCD pixels per display pixel, the diaphragm, the dynamic range, and the exposure time
 - For pursuit systems, the synchronization accuracy
 - Light measuring device (luminance meter, color analyzer, spectroradiometer, other)
 - Scroll speed(s) (ex. 8 pixels/frame)
 - Gray levels (start levels and end levels)
 - Test pattern(s) details
 - Other measuring conditions, such as shutter speed of the camera, frame frequency, etc.
- Analysis method
 - Parameter (EBET, BET, PBET)
 - Threshold for EBET or BET calculation, e.g. 10% - 90%
 - Type of CSF and the CSF parameters for PBET calculation.



Visually reporting

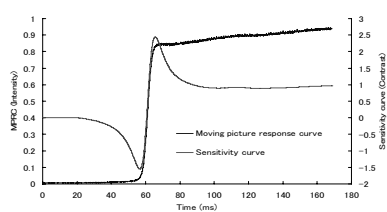
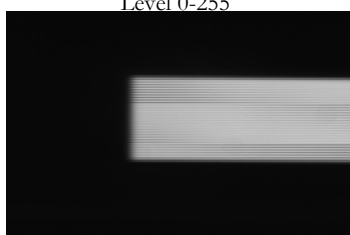


動画ボヤケの評価の実例

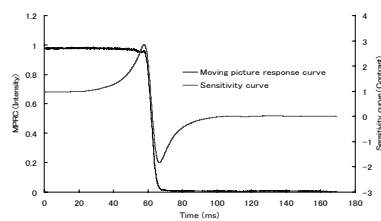
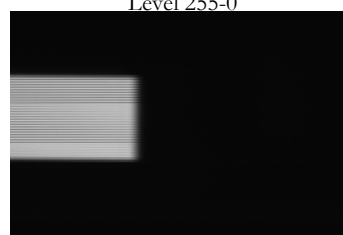


Pursuit detection system

Level 0-255



Level 255-0



サンプル : 3D対応TV/ 4倍速駆動対応/ LED バックライト
測定条件 : 12 pixel/frame / 1080i



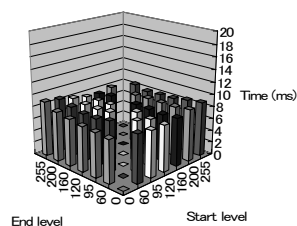
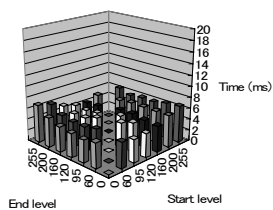
Pursuit detection system (MPRT-2000UX)

EBET

EBET(ms)		0	60	95	120	160	200	255
Start\End	0	---	4.49	4.06	4.26	4.56	5.31	6.89
	60	4.61	---	5.06	4.59	4.58	5.03	6.14
	95	4.15	6.13	---	5.28	4.46	4.46	5.09
	120	4.25	5.30	5.70	---	4.69	4.30	4.55
	160	4.68	4.93	5.26	5.19	---	4.43	4.18
	200	5.80	5.76	5.66	5.73	5.53	---	5.03
	255	6.63	6.44	6.00	5.94	5.66	6.41	---
Average		5.17						
Maximum		6.89						
Minimum		4.06						

PBET

PBET(ms)		0	60	95	120	160	200	255
Start\End	0	---	7.07	7.28	7.38	7.7	8.12	8.97
	60	7.91	---	8.23	7.81	7.81	8.23	8.75
	95	7.59	8.23	---	8.12	7.81	7.91	8.23
	120	7.59	7.7	8.12	---	7.91	7.81	7.7
	160	7.91	7.7	7.81	7.81	---	7.91	7.59
	200	8.44	8.23	8.12	8.23	8.02	---	8.02
	255	8.86	8.54	8.23	8.12	8.02	8.54	---
Average		8						
Maximum		8.97						
Minimum		7.07						

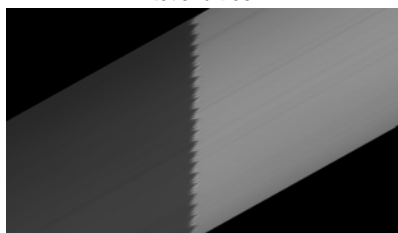


サンプル : 3D対応TV/ 4倍速駆動対応/ LED バックライト
 測定条件 : 12 pixel/frame / 1080i

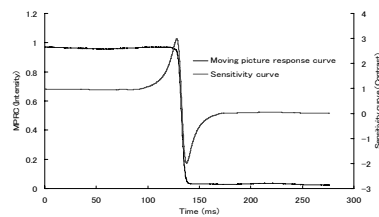
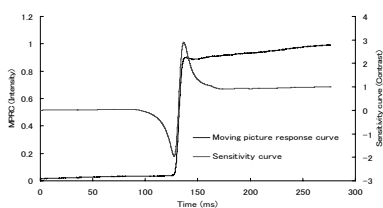
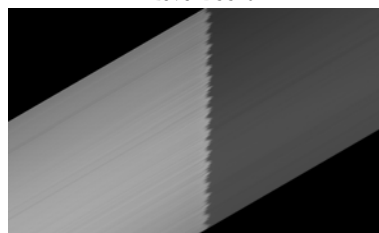


High speed camera (MPRT-C100)

Level 0-255



Level 255-0



サンプル : 3D対応TV/ 4倍速駆動対応/ LED バックライト
 測定条件 : 12 pixel/frame / 1080i



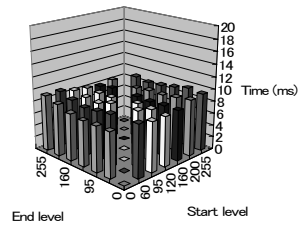
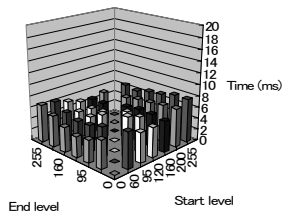
High speed camera (MPRT-C100)

EBET

EBET(ms)	Start	End	0	60	95	120	160	200	255
0	---	---	4.84	3.94	3.65	4.35	5.50	6.66	
60	6.25	---	---	5.26	4.68	4.54	5.28	6.50	
95	5.23	7.00	---	---	5.71	4.50	4.65	5.66	
120	5.18	6.11	6.23	---	---	4.61	4.49	4.98	
160	5.41	5.73	5.80	5.46	---	---	4.64	4.68	
200	6.74	6.59	6.29	6.11	5.70	---	---	5.24	
255	7.61	7.71	7.14	6.79	6.26	6.64	---	---	
Average			5.63						
Maximum			7.71						
Minimum			3.65						

PBET

PBET(ms)	Start	End	0	60	95	120	160	200	255
0	---	---	7.43	7.43	7.43	7.77	8.46	9.15	
60	8.63	---	---	8.46	8.12	7.94	8.46	9.15	
95	8.12	8.98	---	---	8.63	7.94	8.12	8.63	
120	8.12	8.46	8.63	---	---	8.12	8.29	7.94	
160	8.29	8.29	8.12	8.29	---	---	8.29	8.46	
200	9.15	8.81	8.63	8.63	8.29	---	---	---	
255	9.5	9.67	9.15	8.81	8.63	8.98	---	---	
Average			8.44						
Maximum			9.67						
Minimum			7.43						

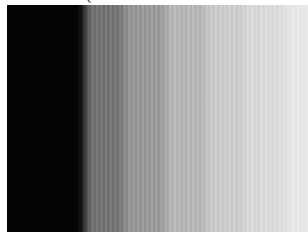


サンプル : 3D対応TV/ 4倍速駆動対応/ LED バックライト
 測定条件 : 12 pixel/frame / 1080i

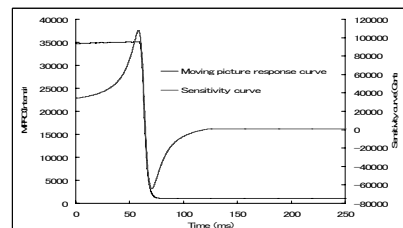
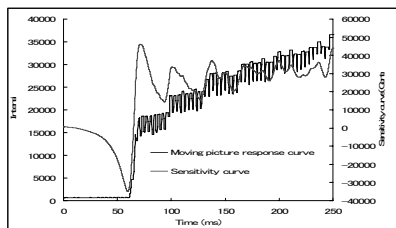
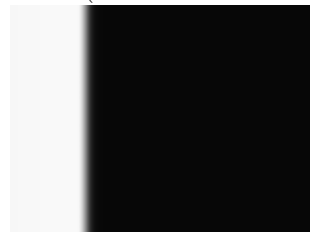


Temporal step response (RT-300)

Level 0-255(応答曲線から求めた画像)



Level 255-0(応答曲線から求めた画像)



サンプル : 3D対応TV/ 4倍速駆動対応/ LED バックライト
 測定条件 : 12 pixel/frame / 1080i



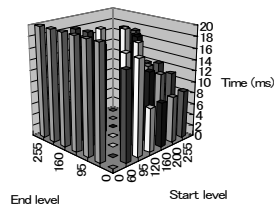
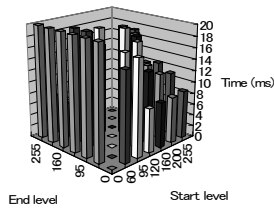
Temporal step response (RT-300)

EBET

Start/End	0	60	95	120	160	200	255
0	---	87.22	93.72	107.34	147.79	118.86	150.83
60	15.68	---	18.64	39.53	29.43	6.27	6.97
95	16.92	17.14	---	21.27	18.76	15.64	5.55
120	7.81	18.25	23.53	---	16.56	14.96	5.03
160	7.98	12.69	18.16	17.58	---	14.65	14.25
200	8.17	11.62	12.47	17.46	17.73	---	13.85
255	8.47	11.05	12.34	11.81	17.26	17.33	---
Average	29.73						
Maximum	150.83						
Minimum	5.03						

PBET

Start/End	0	60	95	120	160	200	255
0	---	43.45	183.94	189.7	183.94	10.9	11.06
60	20.87	---	19.94	19	19.31	10.75	11.53
95	20.09	20.4	---	20.09	19.47	18.38	10.75
120	11.68	19.31	19.78	---	18.85	18.07	10.28
160	11.84	11.21	18.69	18.38	---	18.07	17.44
200	12.15	11.21	11.84	18.38	18.38	---	17.6
255	12.3	11.84	11.68	11.84	18.69	18.85	---
Average	28.62						
Maximum	189.7						
Minimum	10.28						



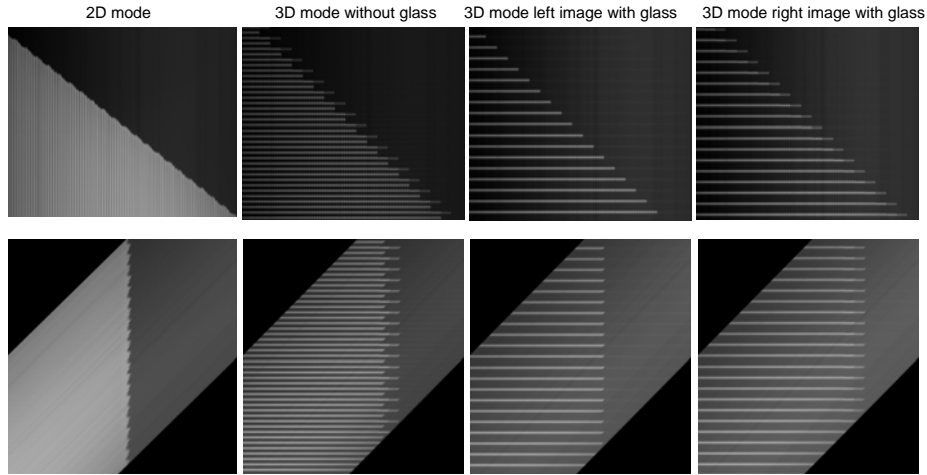
サンプル : 3D対応TV/ 4倍速駆動対応/ LED バックライト
 測定条件 : 12 pixel/frame / 1080i



3Dディスプレイにおける 動画ボヤケの評価の御紹介



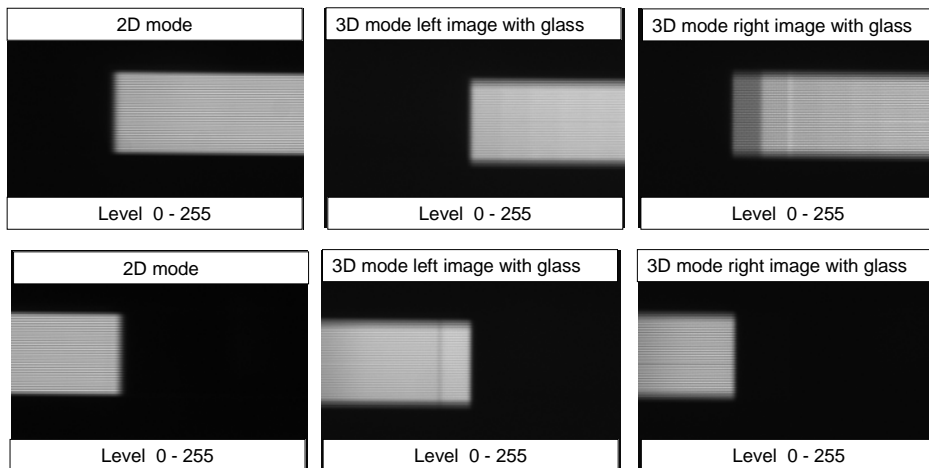
フレームシーケンシャル方式3Dディスプレイ High speed camera (MPRT-C100)



サンプル : 3D表示(フレームシーケンシャル方式)/ 4倍速駆動対応/ LED バックライト
測定条件 : 12 pixel/frame / 1080i



フレームシーケンシャル方式3Dディスプレイ Pursuit detection system (MPRT-2000UX)



サンプル : 3D表示(フレームシーケンシャル方式)/ 4倍速駆動対応/ LED バックライト
測定条件 : 12 pixel/frame / 1080i



フレームシーケンシャル方式3Dディスプレイ Pursuit detection system (MPRT-2000UX)

静止画

Left image with glass

Right image with glass



動画
追従画像

2D mode

3D mode left image with glass

3D mode right image with glass

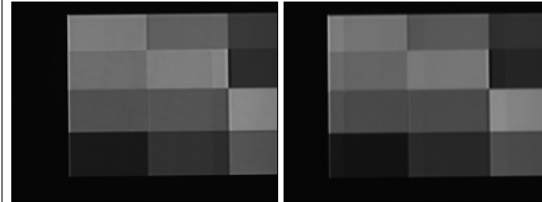


フレームシーケンシャル方式 2D→3D mode

静止画

3D mode left image with glass

3D mode right image with glass

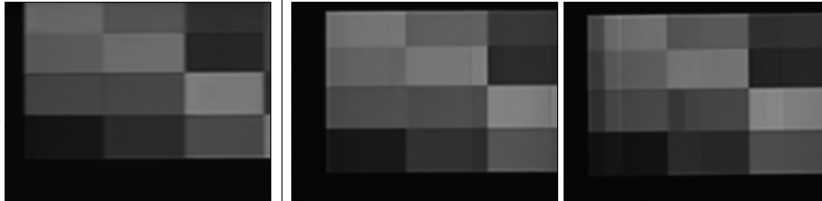


動画
追従画像

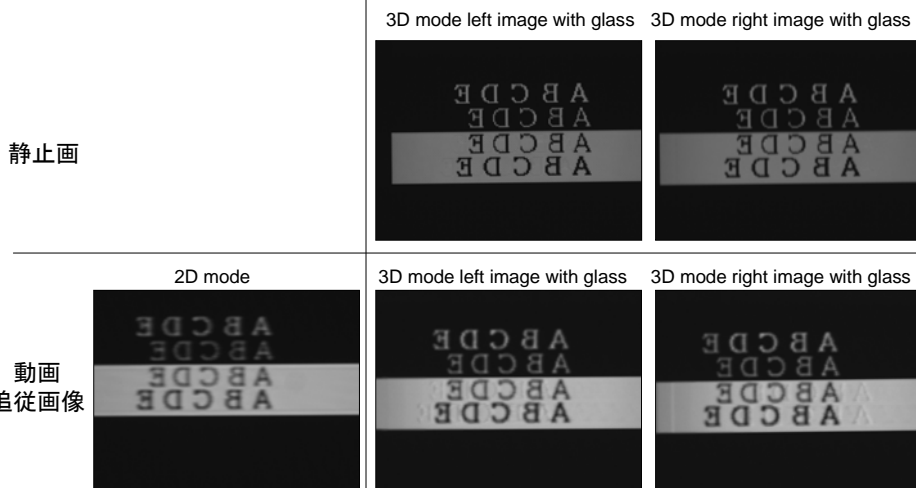
2D mode

3D mode left image with glass

3D mode right image with glass



フレームシーケンシャル方式3Dディスプレイ Pursuit detection system (MPRT-2000UX)



フレームシーケンシャル方式3Dディスプレイ Pursuit detection system (MPRT-2000UX)

2D mode / EBET

EBET(ms)	Start	End	0	60	95	120	160	200	255
0	---	---	4.84	3.94	3.65	4.35	5.50	6.66	---
60	6.25	---	---	5.26	4.68	4.54	5.28	6.50	---
95	5.23	7.00	---	---	5.71	4.50	4.65	5.66	---
120	5.18	6.11	6.23	---	---	4.61	4.49	4.98	---
160	5.41	5.73	5.80	5.46	---	---	4.64	4.68	---
200	6.74	6.59	6.29	6.11	5.70	---	---	5.24	---
255	7.61	7.71	7.14	6.78	6.26	6.64	---	---	---
Average	5.63	---	---	---	---	---	---	---	---
Maximum	7.71	---	---	---	---	---	---	---	---
Minimum	3.65	---	---	---	---	---	---	---	---

2D mode / PBET

PBET(ms)	Start	End	0	60	95	120	160	200	255
0	---	---	7.43	7.43	7.43	7.77	8.46	9.15	---
60	8.63	---	---	8.46	8.12	7.94	8.46	9.15	---
95	8.12	8.98	---	---	8.63	7.94	8.12	8.63	---
120	8.12	8.46	8.63	---	---	8.12	8.12	8.29	---
160	8.29	8.29	8.12	8.29	---	---	8.29	7.94	---
200	9.15	8.81	8.63	8.63	8.29	---	---	8.46	---
255	9.5	9.67	9.15	8.81	8.63	8.98	---	---	---
Average	8.44	---	---	---	---	---	---	---	---
Maximum	9.67	---	---	---	---	---	---	---	---
Minimum	7.43	---	---	---	---	---	---	---	---

3D mode left image with glass / EBET

EBET(ms) 3D mode left image	Start	End	0	60	95	120	160	200	255
0	---	---	16.01	2.53	2.90	3.06	3.99	5.06	---
60	1.36	---	---	2.74	2.79	2.98	3.56	4.46	---
95	2.21	1.94	---	---	2.90	2.74	3.29	4.24	---
120	2.59	2.51	2.24	---	---	2.73	3.26	3.84	---
160	2.90	2.84	2.59	2.60	---	---	3.04	3.88	---
200	3.74	3.31	3.06	2.73	2.93	---	---	3.86	---
255	4.33	4.18	3.93	3.55	3.16	3.88	---	---	---
Average	3.49	---	---	---	---	---	---	---	---
Maximum	16.01	---	---	---	---	---	---	---	---
Minimum	1.36	---	---	---	---	---	---	---	---

3D mode left image with glass / PBET

PBET(ms) 3D mode left image	Start	End	0	60	95	120	160	200	255
0	---	---	5.7	5.87	6.04	6.22	6.91	7.43	---
60	6.74	---	---	6.04	6.04	6.22	6.74	7.43	---
95	6.04	6.56	---	---	6.56	6.22	6.74	7.25	---
120	6.22	6.22	6.22	---	---	6.22	6.56	7.08	---
160	6.39	6.39	6.04	6.04	---	---	6.56	6.91	---
200	6.91	6.91	6.74	6.39	6.56	---	---	7.25	---
255	7.43	7.43	7.43	7.08	6.56	7.43	---	---	---
Average	6.81	---	---	---	---	---	---	---	---
Maximum	7.43	---	---	---	---	---	---	---	---
Minimum	5.70	---	---	---	---	---	---	---	---

3D mode right image with glass / EBET

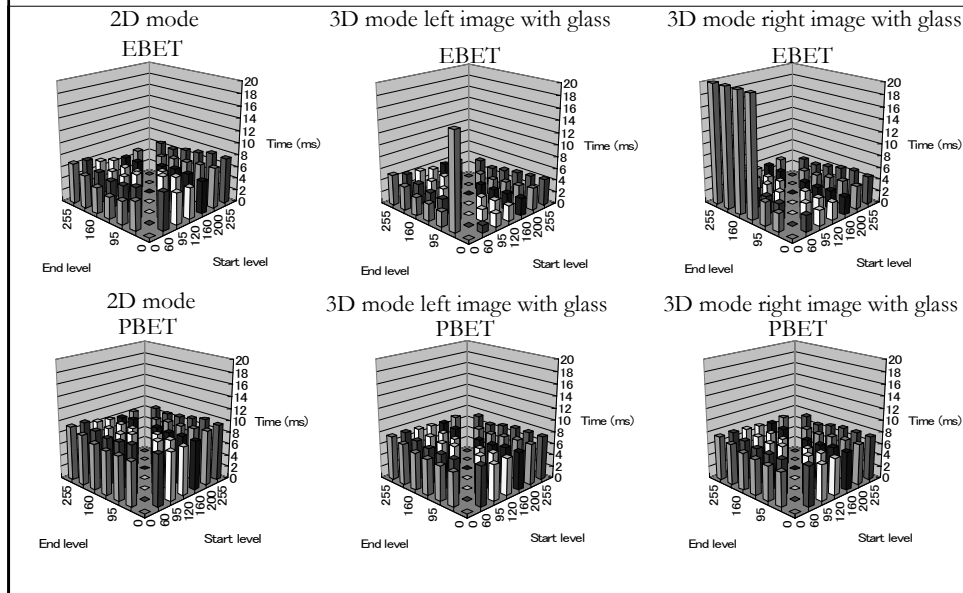
EBET(ms) 3D mode right image	Start	End	0	60	95	120	160	200	255
0	---	---	3.04	3.90	22.30	22.83	23.39	23.54	---
60	2.75	---	---	2.76	3.04	3.29	3.84	4.74	---
95	2.61	2.90	---	---	2.90	3.38	3.60	4.15	---
120	2.94	2.76	3.08	---	---	3.08	3.09	3.85	---
160	2.96	3.10	2.83	2.88	---	---	3.10	3.41	---
200	3.90	3.94	3.75	3.33	3.25	---	---	3.86	---
255	4.64	4.94	4.55	4.15	3.69	3.89	---	---	---
Average	5.32	---	---	---	---	---	---	---	---
Maximum	23.54	---	---	---	---	---	---	---	---
Minimum	2.61	---	---	---	---	---	---	---	---

3D mode right image with glass / PBET

PBET(ms) 3D mode right image	Start	End	0	60	95	120	160	200	255
0	---	---	23.31	5.7	5.87	6.04	23.31	23.14	---
60	6.22	---	---	6.56	6.39	6.39	6.56	7.25	---
95	6.04	6.22	---	---	6.39	6.22	6.56	6.91	---
120	6.39	6.39	6.56	---	---	6.04	6.39	6.91	---
160	6.39	6.56	6.39	6.56	---	---	6.56	6.91	---
200	6.74	6.91	6.74	6.56	6.56	---	---	7.08	---
255	7.43	7.6	7.25	7.08	6.74	7.25	---	---	---
Average	7.79	---	---	---	---	---	---	---	---
Maximum	23.31	---	---	---	---	---	---	---	---
Minimum	5.70	---	---	---	---	---	---	---	---



フレームシーケンシャル方式3Dディスプレイ Pursuit detection system (MPRT-2000UX)



まとめ

- Pursuit detection system
 - 一般的な手法として認識されている。
 - 人が動画として認識する画像に近い画像を得ることができる。
 - 高精度な追従機構が要求される必要である。
- High speed camera
 - 時間的な画像の描画プロセスを確認できる。
 - 駆動機構がなく設置が容易である。
 - 高速で画像情報を捉えるためPursuit detection systemと同様の結果を得ることができる。
- Temporal step response
 - 他のシステムに比べて簡単で廉価である。
 - フレーム周波数が既知であるサンプルでしか求めることができない。
 - ステップ応答を用いて測定するので、求めた動画応答曲線に画像処理情報が付加されなく、Pursuit detection systemやHigh speed cameraとは異なった結果が出る場合がある。
- BET, EBETについて
 - MPRT解析手法 (FPDM2 Update)と同様の手法が採用されており、使用において混乱が避けられている。
 - 評価階調や閾値は限定されておらず、評価シートに明記することで臨機応変に対応することができる。
- PBETについて
 - 新たに採用された手法であり、今後どのように使用されるかを期待したい。

Thank you for your attention.

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