Power-constrained contrast enhancement algorithm using multi scale retinex for OLED display

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Abstract

Digital image processing domain achieves revolutionary development in 21st century and various research fields like medicine, genetics, security, robotics, pattern recognition has registered enormous growth because of digitalization. Digitalization has increased power consumption which tends to design power constrained algorithms to preserve power and to visualize digital content in better way.. In this work a new power constrained algorithm is proposed for OLED emissive display devices based on Multi scale retinex (MSR) mechanism. The MSR comprises of two steps namely (i) power controllable log operation and (ii) sub-band gain control. Calculation of gain factor for each MSR after decomposing the input image into respective sub bands is the initial step performed and coarse-to-fine power control mechanism is the latter step followed by gain factor. These two steps iteratively repeated until target power saving is accurately accomplished. Finally experimental results reveal that proposed method achieves high quality perception and nearly chive good gain in videos by handling the flickering artifacts in reasonable way.

Keywords: Power constrained, OLED, gain factor, MSR, power controllable log operation

1. INTRODUCTION

The immense development and improvement in the area of digital image processing makes the processing of digital photography easy and simple. Generally due to the continuous variation in the lighting conditions and variations in the other factors we acquire the low quality photographs. Due to the changes in the real time lighting conditions instead of high quality photographs we acquire the low quality photographs, further to enhance the quality of low quality images we have to improve the several parameters and factors which are related to the digital image in order to yield the high end high quality images in place of low quality images. The factors related to digital image to improve the quality are contrast, brightness levels, decreasing the noise impact on image etc. Naturally a question arises why we have to convert the low quality digital image to the high quality digital image or why we have to enhance the quality of digital image. We have to improve the quality of digital image in order to view it in the pleasant way and makes it pleasant whenever we viewing it by the human visual system.

In order to enhance the low quality digital we need opts for the better enhancement techniques which are already exist. In the category of enhancement techniques most successful and highly used enhancement technique is contrast enhancement technique. The most important thing taken into consideration while enhancing the low quality digital images is the necessary technique must adaptive to the respective relative displays especially the contrast enhancement technique. In literature so many frameworks and algorithms are proposed but most of the algorithms are based on the enhancement. Lot of research has been to improve the digital quality based on not only enhancement techniques but also merely on the power saving also simultaneously.

The 21st century is considered as digital devices periods by the most of the researchers because of the immense development and high advance development in the area of digital image processing. Most of the multimedia devices such as mobile phones, laptops, personal computers consume more power as we increase the brightness and contrast levels. So power saving is an area of concern from dew years. In order improve the better perceptual quality of the respective image along the enhancement we have to improve the power saving levels too. The main drawback in assessing the power consumption is that power consumption of display devices increases along with the resolution (size) of display devices.

As one of them retinex is a remarkable non-straight improvement technique utilized for differentiation upgrade and in addition element range pressure. The retinex hypothesis was proposed via Land and McCann and Jobson et al. adjusted their hypothesis to single scale retinex (SSR) and multi-scale retinex (MSR). Retinex hypothesis accept that the human visual framework has three autonomous approaches to see short, medium, and long wavelengths in the obvious light range. In light of the retinex hypothesis, SSR uses Gaussian low pass channel (LPF) and log operation to highlight a particular wavelength scope of the picture, and MSR gives a yield picture as the weighted aggregate of the retinex yield pictures by utilizing a few direct LPFs having diverse bolster local.

2. BACKGROUND

2.1. POWER CONSUMPTION

In electrical building, force utilization frequently alludes to the electrical vitality over the long run supplied to work an electrical machine. The vitality utilized by hardware is constantly more than the vitality truly required. This is on the grounds that no hardware is 100% productive. Force is squandered as warmth, vibrations and/or electromagnetic. Power utilization is typically measured in units of kilowatt hours (kWh). All the more precisely, power is the rate of utilization of vitality, measured in watts or pull. Electric vitality utilization is the type of vitality utilization that uses electric vitality. Electric vitality utilization is the real vitality request made on existing power supply. But in Asia and Middle East, utilizations were lessened in all the world locales.

The OECD nations which represents 53% of the aggregate, power interest downsized by more than 4.5% in both Europe and North America while it shrank by over 7% in Japan. Generally Power request additionally dropped by more than 4.5% in CIS nations, driven by a substantial cut in Russian utilization. On the other hand, in China and India (22% of the world's utilization), power utilization kept on ascending at an in number pace (+6-7%) to take care of vitality demand identified with high financial development. In Middle East, development rate was diminished however stayed high, just beneath 4%.

2.2. CONTRAST ENHANCEMENT

Contrast is the difference in visual properties that makes an object (or its representation in an image) distinguishable from other objects and the background. In visual perception of the real world, contrast is determined by the difference in the color and brightness of the object and other objects within the same field of view. In other words, it is the different between the darker and the lighter pixel of the image, if it is big the image will have high contrast and in the other case the image will have low contrast.

Figure 1: On the left half low contrast, and on the right half high contrast image

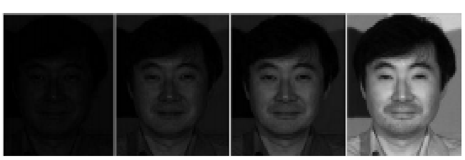

Figure 2: contrast enhancement images

2.3. OLED

A natural OLED is a light-transmitting diode (LED) in which the emissive electroluminescent layer is a film of natural compound which emanates light because of an electric current. This layer of natural semiconductor is arranged between two terminals; commonly, no less than one of these anodes is straightforward. OLEDs are utilized to make advanced shows in gadgets, for example, TV screens, PC screens, convenient frameworks, for example, cellular telephones, handheld amusement reassures and PDAs. A noteworthy range of examination is the advancement of white OLED gadgets for utilization in strong state lighting applications. There are two principle groups of OLED: those in light of little particles and those utilizing polymers. Adding portable particles to an OLED makes a light-transmitting electrochemical cell (LEC) which has a marginally diverse mode of operation. OLED presentations can utilize either detached matrix (PMOLED) or dynamic network tending to plans.

An OLED showcase lives up to expectations without a backdrop illumination; therefore, it can show profound dark levels and can be more slender and lighter than a fluid precious stone display(LCD). In low encompassing light conditions, (for example, a dim room), an OLED screen can accomplish a higher complexity proportion than a LCD, paying little mind to whether the LCD uses chilly cathode fluorescent lights or a LED backdrop illumination

3. PROPOSED METHOD

3.1 Sub-Band decomposed multi-Scale retinex

MSR is an extended SSR with multiple kernel windows of different sizes. MSR output is a weighted sum of several different SSR outputs . The MSR output for a single spectral component can be represented as

$$R^{MSR}(x,y) = \sum_{n=1}^{N} w_n . R_n(x,y) \quad (1)$$

where

$$R_n(x,y) = logI(x,y) - \log(F_n(x,y) * I(x,y)) \qquad (2)$$

Here $R_n(x,y)$,denotes a retinex output associated with the n-the scale for an input image $I(x,y)$.Note that gain wn is determined so that it can satisfy the condition of $\sum w_n = 1$. The symbol "*" in Eq. (2) denotes the convolution operation and Nis the number of scales. $F_n(x,y)$Denotes a surround function and is given by

$$F_n(x,y) = K_n e^{(x^2+y^2)/\sigma_n^2} \qquad (3)$$

Where K_n is determined so that $F_n(x,y)$ can satisfy $\sum\sum F_n(x,y) = 1$. σ_n^2 denotes the variance of the Gaussian kernel at then-the sub-band. Under the condition $\sigma_n > \sigma_{n-1}$ every SSR, we can derive successive frequency sub-bands. Note that a small is suitable for enhancing fine details, whereas a Largent is suitable for improving tonality. Thus, it is important to select an appropriate value of an in the MSR. Based on this rationale, Jang et al. proposed an SD-MSR that consists of a modified logarithmic function, sub-band decomposition, space varying sub-band gain, and an automatic gain/offset control [16] (see Fig. 1). The modified log (mlog) is defined as

$$mlog(I(x,y)) = \begin{cases} w_L \log(I(x,y)+1) & I(x,y) \le \tau \\ -w_H \log(D - I(x,y)) + logD & I(x,y) > \tau \end{cases} \qquad (4)$$

Where τ is a user-defined threshold and D denotes an image dynamic range. For example, D is 256 for an 8-bit image

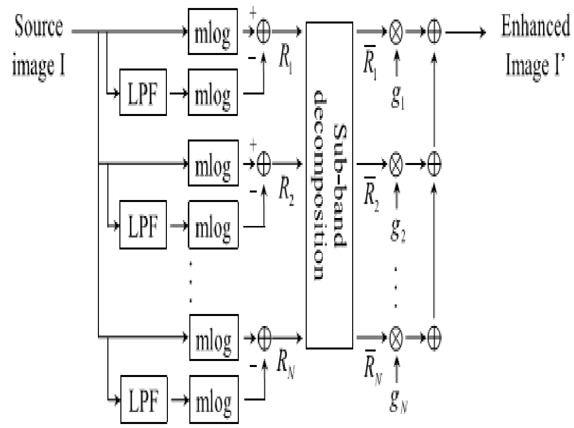

Figure 3: Block diagram of the conventional SD-MSR

w_L And w_L denote weighting parameters according to and are defined as

$$w_L = \frac{\frac{\tau}{D-1}logD}{\log(\tau+1)}, \quad w_L = \frac{(1-\frac{\tau}{D-1})logD}{\log(D-1)} \qquad (5)$$

s a result, the mlog function of Eq. (4) enhances the contrasts of dark regions as well as bright regions. In this way, we can enhance image details both in highlights and shadows. Another feature of SD-MSR is to decompose the modified retinex outputs into nearly non-overlapping spectral bands. The following equation accomplishes this sub-band decomposition:

$$\bar{R}_1 = R_1 n = 1$$

$$\bar{R}_n = R_n - R_{n-1} \qquad 2 \le n < N \qquad (6)$$

As n increases, Rn corresponds to the low frequency region n more and more. Here, Rn is computed by replacing the log of Eq. (2) With the mlog of Eq. (4) Next, the space vary in g sub-band gain at then-the sub-band is defined as

$$g_n(x,y) = \left(\frac{1}{NR_n(x,y) + \varepsilon_g}\right)^{1-\frac{\sigma n}{\sigma max + \varepsilon\sigma}} \qquad (7)$$

Where

$$\sigma_{max} = \max_{n\epsilon[1,2,3\ldots N]} \sigma_n$$

$$NR_n(x,y) = \frac{|\bar{R}_n(x,y)|}{\bar{R}_{n_{max}}} \quad (8)$$

In a high spectral band of small, they make the gain difference between pixels larger, especially for the pixels with low $NR_n(x,y)$. This is because this spectral band has large high-frequency components representing image details. Meanwhile, they lower the gain difference between pixels in a high spectral band of large n to maintain the characteristics of a natural scene. Thus, using Eq. (7), the final enhanced imageIis output as follows

$$I' = \sum_{n=1}^{N} g_n \widetilde{R_n} (9)$$

3.2 The Proposed Algorithm

We propose a power governable distinction enhancement algorithm for OLED show primarily based on SD-MSR. Fig. 2 describe the projected formula that consists of three stages. the primary stage coarsely reduces the facility of Associate in Nursing input image nearer to the target power with distinction improvement, and the second stage finely controls the image power such that it's terribly near the target power. If the input could be a video sequence, the ultimate stage adjusts the facility of every image so that it is like those of its neighbors by considering the temporal coherence of the input video sequence. The projected formula is differentiated from previous methods in the following 3 aspects. First, we tend to control the target power level mechanically. Second, we tend to avoid theflickering development by keeping the facility levels of adjacent images constant for video sequences. Third, we tend to come through time period process of the projected formula on a all-purpose graphics process unit (GPU) even for full HD video sequences

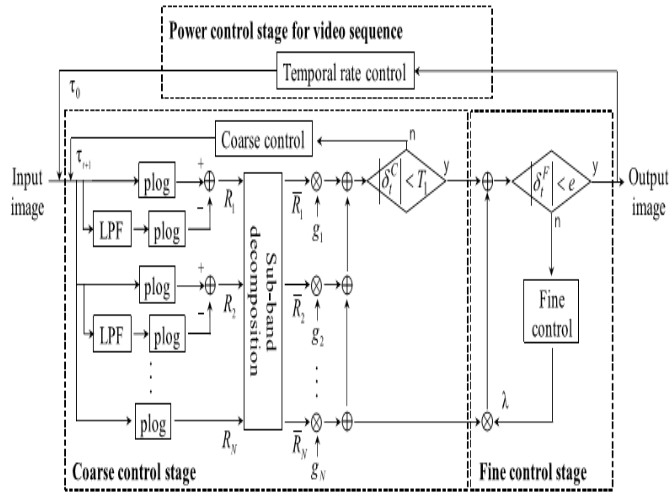

Figure 4: Block diagram of proposed method

Image nearer to the target power with distinction improvement and the second stage finely controls the image power such that it's terribly near the target power. If the input may be a video sequence, the ultimate stage adjusts the ability of every image so that it's the same as those of its neighbors by considering the temporal coherence of the input video sequence. The projected algorithmic program is differentiated from previous methods within the following 3 aspects. First, we have a tendency to control the target power level mechanically. Second, we have a tendency to avoid the flickering development by keeping the ability levels of adjacent images constant for video sequences. Third, we have a tendency to bring home the bacon real-time process of the projected algorithmic program on a general purpose graphics process unit (GPU) even for full HD video sequences.

A. Power Modeling in OLED Display

Before presenting an in depth clarification of the projected algorithmic program, we want to model power for associate OLED show. Dong et al. conferred a pel-based power model that estimates the ability consumption of OLED modules supported the red green-blue (RGB) specification of every pixel [21]. the ability consumption of associate OLED show with K pixels, i.e., P is

$$P_{OLED} = C + \sum_{i=1}^{K}(f_R(R_i) + f_G(G_i) + f_B(B_i)) \quad (10)$$

Also, we consider only the Y-componentbecause it dominates the entire overall power. Note that theY-component indicates the luminance component in YUVcolor format. So we use the Y-component power consumption(YP) of an OLED display with Kpixels [11] as

$$Y_P = \sum_{i=1}^{K} Y_i^{\gamma} \quad (11)$$

Where γ is a parameter for gamma correction for a given display device

B. The Proposed Algorithm

This section details the proposed algorithm.1) Coarse Control Stage: The mlog of conventional SD-MSR plays a role in enhancing the contrasts of highlights and shadow regions. In other words, contrast in the dark region becomes high by increasing the intensity level of the pixels in the region, and contrast in the bright region also becomes high by decreasing the intensity level of the pixels in the region. However, the increase of the intensity values in the shadow region results in the increase in power consumption for the OLED display. So, for low power consumption as well as contrast enhancement, even in the shadow region, we redefine a so-called power-constrained log (plog) from them log of Eq. (4) as follows

$$plog(I(x,y)) = \begin{cases} \frac{\tau log D log(\alpha I(x,y) + 1)}{(D-1)\log(\alpha\tau + 1)} I(x,y) \le \tau \\ mlog(I(x,y)) I(x,y) > \tau \end{cases} \quad (12)$$

Therefore, the $plog$ of Eq. (12) has the effect of controlling the increase in power consumption while partially lowering the contrast in the dark region. From Eq. (7) and MSRs computed by$plog$, i.e., {Rn}, we can derive the following output image

$$\tilde{R}_t = \sum_{n=1}^{N} g_n \hat{R}_n \quad (13)$$

On the other hand, basin YP on Eq. (11), the power reduction ratio of an input image and its output image is defined as follows

$$p_t = 1 - \frac{YP(\hat{\hat{R}}_t)}{YP(I)} \quad (14)$$

In this paper, $\bar{R}_n$ can be computed with Eq. (15) as in [16].

$$f(X) = X^N = \frac{X-m}{M-m}(L-1) + l \quad (15)$$

Let δ_t denote the difference between p_t and P as in Eq. (16)

$$\delta_t = P - p_t \quad (16)$$

Eq. (17) because such a condition indicates an excess of power reduction over P.

$$\tau_{t+1} = \tau_t + {(D - \tau_t)}/{2} \quad (17)$$

we increase τ relatively small as in Eq. (18) because δCt weakly over runs P

$$\tau_{t+1} = \tau_t + {(D - \tau_t)}/{4} \quad (18)$$

So we approach P by decreasing τ relatively small as in Eq. (19).

$$\tau_{t+1} = \tau_t + {\tau_t}/{4} \quad (19)$$

So we rapidly approach P by decreasing τ significantly.

$$\tau_{t+1} = \tau_t + {\tau_t}/{2} \quad (20)$$

On the other hand, the low-frequency region is rarely related to image details, but it dominates image power as a whole. So we try to approach P by finely controlling the proportion of the lowest-band MSR which may have most of the image power. In detail, we control the gain of RN as follows:

$$R^{\wedge} = \sum_{n=1}^{N-1} g_n \bar{R}_n + (g_N + \lambda)\bar{R}_N \quad (21)$$

Where λ indicates a control parameter for the lowest-band MSR.λ, which is updated according to Eq. (22) enables the FCS to approach the target power with little change of contrast

$$\lambda_{t+1} = \lambda_t - \delta_t^F \quad (22)$$

4. SIMULATION RESULTS

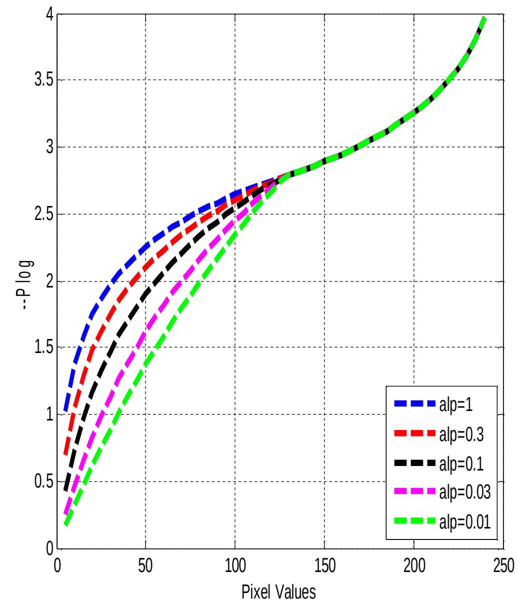

Figure 5: Coarse control stage

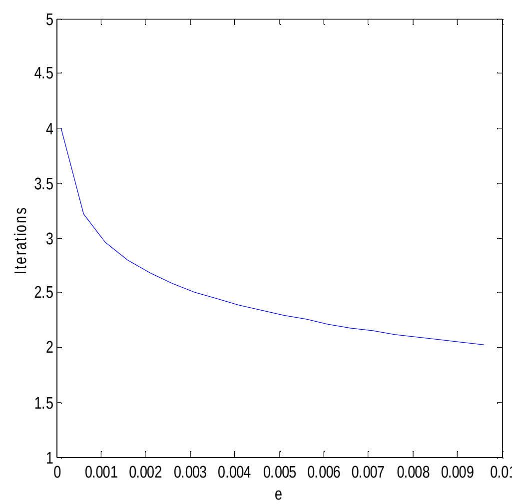

Figure 6: Fine control stage(Iterations)

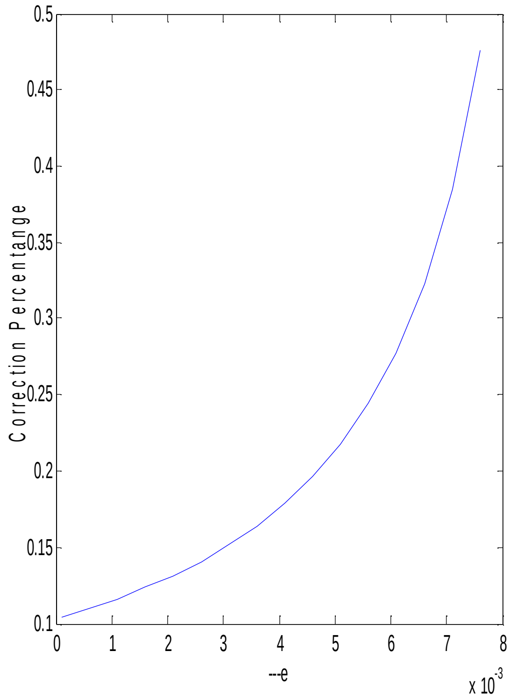

Figure 7: Fine control stage (Correction percentage)

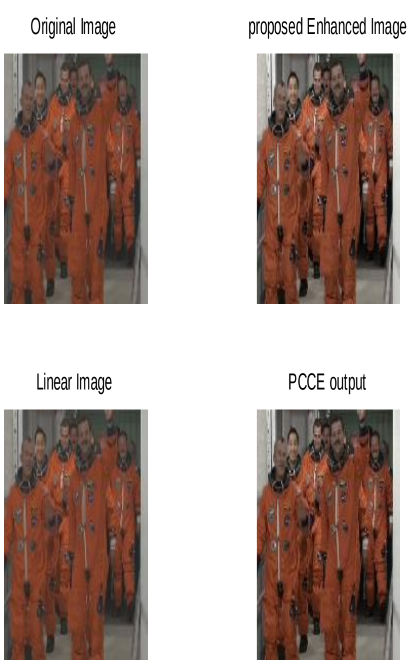

Figure 8: (a) Original image (b) Proposed enhanced image (c) Linear image (d) PCCE output

Table 1: Edge preserving ratio

EDGE PRESERVING RATIO
T1 values

Name	0.03	0.05	0.08	0.1	0.12	0.15
Crew	1.4135	1.4135	1.4135	1.4135	1.4135	1.4135
Paris	1.1076	1.1076	1.1076	1.1076	1.1076	1.1076
Memorial	1.0843	1.0843	1.0843	1.0843	1.0843	1.0843
Caps	1.2323	1.2323	1.2323	1.2323	1.2323	1.2323
Football	1.1995	1.1995	1.1995	1.1995	1.1995	1.1995
Beach	1.2433	1.2433	1.2433	1.2433	1.2433	1.2433

Table 2: Comparison in terms of EPR

Comparison in terms of EPR

Name	P=10%			P=30%		
	Linear	PCCE	Prop	Linear	PCCE	Prop
Crew	0.3971	0.4962	1.4501	0.3971	0.4962	1.6113
Paris	0.5395	0.5734	1.1007	0.5394	0.5734	1.1694
Memorial	0.5377	0.5735	1.0840	0.5382	0.5735	1.1421
Caps	0.2881	0.3253	1.2152	0.2882	0.3253	1.3149
Football	0.4292	0.5027	1.1890	0.4297	0.5027	1.3305
Beach	0.3199	0.3934	1.2396	0.3199	0.3934	1.3639

Table 3: Comparison in terms of EMR

Comparison in terms of EME

Name	P=10%			P=30%		
	Linear	PCCE	Prop	Linear	PCCE	Prop
Crew	3.7313	23.895	24.923	3.7313	19.667	22.960
Paris	15.879	37.924	52.384	15.879	36.839	52.002
Memorial	8.6366	41.404	74.652	8.6366	39.366	77.509
Caps	7.4345	23.286	30.871	7.4345	20.223	31.116
Football	28.518	41.282	61.722	28.518	40.719	62.407
Beach	4.022	14.527	15.534	4.022	12.584	14.079

Table 4: Comparison in terms of sharpness enhancement metric

Comparison in terms of sharpness enhancement metric

Name	P=10%			Linear	PCCE	Prop
	Linear	PCCE	Prop	3.7313	8.9459	9.7312
Crew	2.5352	3.0642	3.2932	4.2703	4.8236	5.3896
Paris	4.2703	4.8236	5.3895	8.6636	9.1814	9.2872
Memorial	3.1591	2.8879	3.1944	5.4616	6.2777	6.8848
Caps	1.8205	2.1463	2.1463	8.7876	9.6404	10.281
Football	2.9292	3.2727	3.4491	5.4734	6.5443	6.8868
Beach	1.8245	2.179	2.2865			

Table 5: Comparison in terms of dynamic range compression

Performance of dynamic range compression

Name	S.N	S.F	Q	S.N	S.F	Q	S.N	S.F	Q
	0.37	0.99	0.90	0.43	0.99	0.91	0.53	0.99	0.92
Crew	0.84	1	0.97	0.77	0.99	0.96	0.83	0.99	0.97
Football	0.32	0.99	0.88	0.65	0.99	0.94	0.24	0.99	0.87
Beach	0.02	0.99	0.81	0.04	0.99	0.82	0.01	0.98	0.80
Memorial	0.49	0.99	0.92	0.17	0.99	0.85	0.09	0.99	0.83
Paris	0.69	0.98	0.95	0.68	0.98	0.95	0.83	0.99	0.97
Caps									

Table 6: power reduction ratio

Power reduction ratio

Name	Target power								
	10%	20%	30%	40%	50%	60%	70%	80%	90%
crew	9.3052	19.288	29.27	39.24	49.22	59.18	69.14	79.08	88.97
Foot ball	9.3121	19.299	29.27	39.253	49.226	59.19	69.148	79.08	88.97
Beach	9.3045	19.286	29.265	39.240	49.210	59.172	69.122	79.04	88.915
Memoria l	9.36	19.347	29.333	39.317	49.299	59.276	69.246	79.206	89.14
Paris	9.3199	19.303 5	29.284 6	39.262	49.235	59.202	69.158	79.096	88.987
Caps	9.3076	19.290 9	29.271 6	39.249	49.221	59.188	69.143	79.079	88.968

Table 7: Comparison of flickering artifacts

Comparison of flickering artifacts

	Proposed	PCCE
Crew	0.0089	0.0491
Foreman	0.0051	0.0024
Football	0.0065	0.0128
News	0.0014	0.0026
Paris	0.0045	0.0226

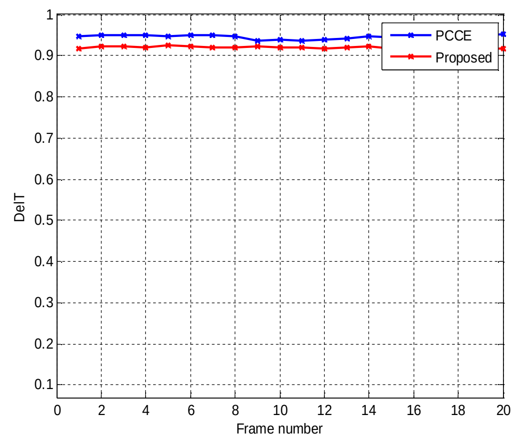

Figure 9: PRR for foremen

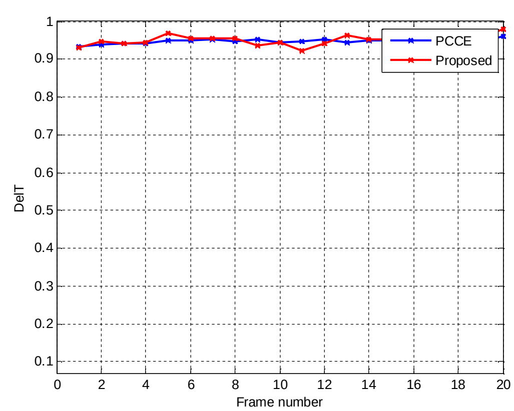

Figure 10: PRR comparison for football video

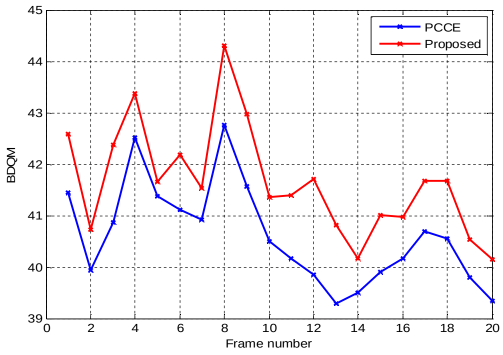

Figure 11: Extension (BDQM)

Advantages: The different manufacturing process of OLEDs lends itself to several advantages over flat panel displays made with LCD technology

5. CONCLUSION

This project proposes an SD-MSR-based image processing algorithm for fine power control in OLED displays. In this designed a power-constrained log function for effective power saving in dark regions. Using the power-constrained log function for SD-MSR and an adaptive weighting strategy proper for an input image, we proposed a coarse-to-fine power control mechanism for still images. Finally, we presented a power control scheme for a constant power reduction ratio in video sequences by using temporal coherence in video sequences. Experimental results showed that the proposed algorithm provides better visual quality than previous works, and a consistent power-saving ratio without the flickering artifact even for video sequences. Specifically, the proposed algorithm provides at maximum 36% and on average 13% higher edge-preserving ratios than the state-of-the-art algorithm (i.e., PCCE [11]). In addition, we proved the possibility of real-time processing by accomplishing an entire execution time of 9 ms per 1080p image.

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