P-189: On the performance of Multi-Valued Image Entropy Coding for LCD source drivers

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Abstract
Multi-Valued Image Entropy Coding (MVIEC) is a new class of joint source channel coding, which reduces both input-width (1/4) and average current (0.36-1.3) for LCD source drivers. This paper describes the detail results on MVIEC for several image sets in order to verify the practical performance.

1. Introduction.
The rapid increase of image size causes not only EMI problem but also input wiring (wide bus) problem in aiming to PCB-less or advanced COG. Circuit approaches, such as mini-LVDS, RSDS, CMADS, MSDL, MVI and MPL, seem to terminate these two problems at first look. However, image size still expected to grow more and more, and circuit improvements have limits, therefore the above solutions are still interim. So, further approach based on new principle is desired. For this reason, we are proposing a new transmission technology for LCD source drivers in the companion paper [1]. It is based on the two technologies: multi-valued transmission and image entropy coding. This paper supplements the performance details, not explained in the paper by space limitation.

2. Performance Analysis on MVIEC.
MVIEC is based on the fact that prediction error is described by a sharp correlation called extended Laplace distribution. Figure 1 is a typical illustration of such fact. The original image is decomposed into three R, G and B images, and further into R-G and B-G images. As the latter two color-difference images have stronger correlations, we use them with G. Figure 2 shows the statistical distributions by some images, which implicitly suggests that the parameter of extended Laplace distribution is characterized by normal distribution when many images are treated. Most of curves are located around the center of "typical Laplace curve". See the details of our entropy coding [1]: how to exploit such distribution.

set name	Average current	# of images	Size and format
pc	8.8 mA (36%)	14	1280x1024 bmp (screen dump)
science fiction	11 6 mA (48%)	25	720x480 bmp (DVD MPEG2)
amine	12.0 mA (50%)	52	720x480 bmp (DVD MPEG2)
national park	13.4 mA (59%)	75	720x480 bmp (DVD MPEG2)
mystery	12.1 mA (50%)	30	720x480 bmp (DVD MPEG2)
master piece	16 3 mA (68%)	32	various size 417x543 average, JPEG (from TNM web)
America	30.4 mA (127%)	100	640x480 TIFF (CDROM photo)
sakura	31.2 mA (130%)	72	640x480 JPEG (CDROM photo)

Table 1. Performance list of image sets

Table 1 shows the list of image sets, including the average current of analysis results, the number of images to be analyzed, their image size, and their image format. The format described in the table specifies the original format: it means the transmitted image is not compressed image data. The image is de-compressed and transmitted. As some formats are lossy, they have effects on the entropy. Figure 3 shows some of analyzed images for some image sets.

The image set "pc" is a collection of screen dumps that appear in typical computer operation including MINITAB © statistical analysis for MED error distribution, MATLAB © analyses for MED error generation, paper searches in societies (IEEE, ACM, SPIE, IS&T, SID) digital library, patent searches in US patent office web site and so on.

The image sets "science fiction", "anime", "national park", "mystery" are collections of TV images. The "science fiction" has rather darker images like cinema application (in fact, some pictures are really cinema pictures, and have no significant differences). The "anime" is the cartoon, which is expected to have rather simpler painted images. However, its results are not so good as expected (nearly same as others). The "national park" is the collection of sight seeking: national parks, national historical heritages and landmarks. It has many natural images. All these are taken from DVD, and which means 4:2:0 sub-sampling is implicitly applied by using MPEG2 format.

The image set "master piece" is a collection of museum masterpieces found in the web site. You maybe concern that high quality images like museum exhibition is hard to handle just like as "sakura" and "America", but unexpectedly reduced to 70 %. This is because unconsciously aesthetic picture composition selects plain background to let exhibition target or painting-theme emphasized.

The image set "sakura" is a photo-collection of digital camera. This collects the artistic images of cherry trees. The images in winter season are not analyzed because they are so monotonic and simple covered by snow. The image set "America" collects pictures (photo-collection of digital camera) of sight seeking, similar to the images set "national park".

Figure 4 includes the histogram statistics of current estimation for each image set. Analyzed mean value is used to compute total current as follows: ((mean)*4mA + 2.2 mA)*3 for three

16-valued lines. The current 4 mA is a unit of transmission, and 2.2 mA is ADC consumption per line. The conventional current is 24 mA = 4mA*0.5*12 because logical value for 'zero' and 'one' occurs with equal probability 0.5 for 12 lines with 4 mA current amplitude (current unit). For example, the image set "pc" has a mean 0.18, then (0.18*4+2.2)*3 = 8.76 mA, roughly 40% of 24mA.

As the result summary, wire-width is reduced to 1/4 (12 lines to 3) [1], and simultaneously its current is reduced to 50% - 60 % for TV image ("science fiction", "anime", "national park" and "mystery"), to 40% for PC image "pc", and also to 70% for museum exhibition image "master piece". The natural picture images of digital still camera "America" and "sakura" have the additional 30% increase. As we think such camera picture is less frequent (operation time duration is short) compared to both PC operation in work at office and TV watching in couch at home, the additional 30% increase is admissible compared to the drastic increase of the original MVL (which does not adopt our MVIEC technology). The results show that 4:2:0 sub-sampling has good impact to enhance correlation in both natural images and TV-shows. These analyses conclude that PC monitor application is very suitable and TV application is well applicable.

3. Discussion.

We have verified the good performance of our multi-valued image entropy code in many image applications: PC monitors, TV. As impacts, we will add discussions of two potential applications as follows. (1) Monochrome medical images (such as CT, MRI, mammogram, angiogram and X-ray) have very sharp correlation for color difference signals, so it is naturally expected to have good performance. In addition, the "pc" image set suggests that display images of medical software processing such as volume rendering have also small entropy. Therefore applications to medicine seem very suitable. (2) Let's consider the case of movie in mobile phone. MPEG-4 and H.26x image coding inherit the MPEG2 scheme (I-pictures adopt 4:2:0 chroma sub-sampling, and they are source images for the predictions of P and B pictures). So, alpha blending with simple

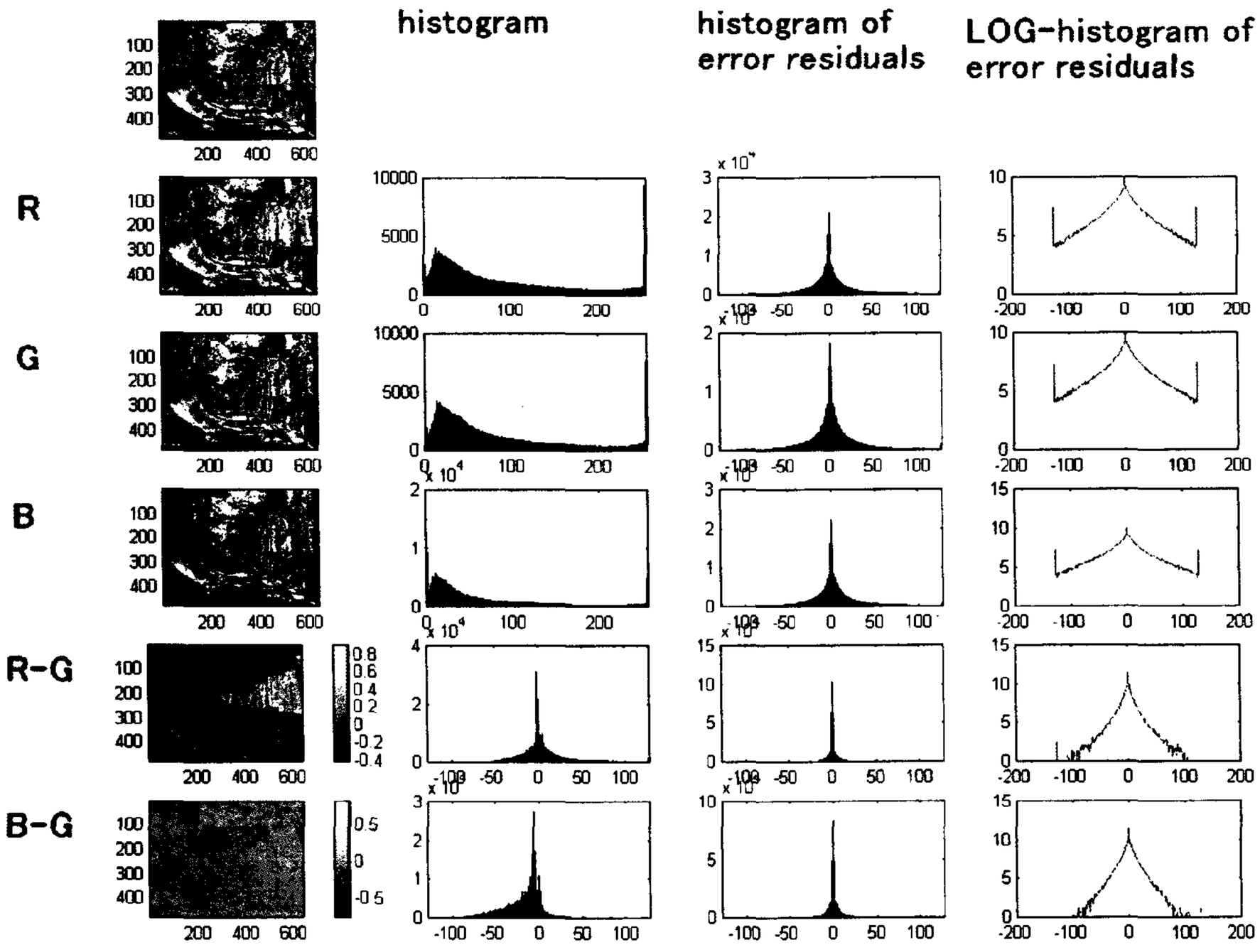


Figure 1: Sample histogram for error distribution by 1H predictor. MED predictor gives results in similar but shaper distribution. Edges of both sides in LOG-histogram should be ignored because the application of MATLAB histogram function here has 8 bits range to compute their histogram. The counts in histogram out of range (over +128 and below –128) are summed in each level.

computer-generated painted image cause less entropy. Therefore, movie applications in mobile phone seem very suitable.

This is the first recognition in MVIEC image transmission that the popular chroma sub-sampling works very positively. Most of lossless data compression engineer forgets the chroma sub-sampling, because they are focusing on lossless technology. In addition, our analysis also suggests that the chroma sub-sampling works in EMI suppression [2].

4. Conclusion

We have verified the performance of MVIEC for many image sets. This shows good results, especially for TV pictures to reduce average current consumption.

5. References

[1] Hisashi Sasaki et al., "Multi-Valued Image Entropy Coding for input-width reduction of LCD source drivers," 9-3, Asia Display / IMID '04.

[2] Haruhiko Okumura et al., "Vertically Differential EMI Suppression Method For High-Resolution LCDs." P-53, IDRC 2003

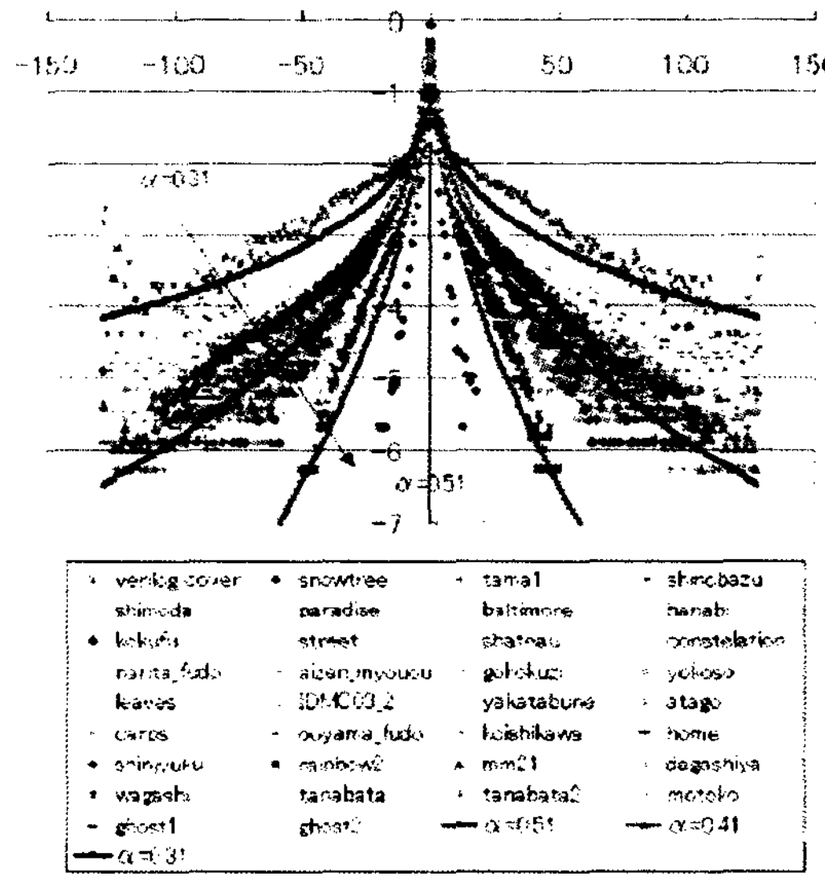
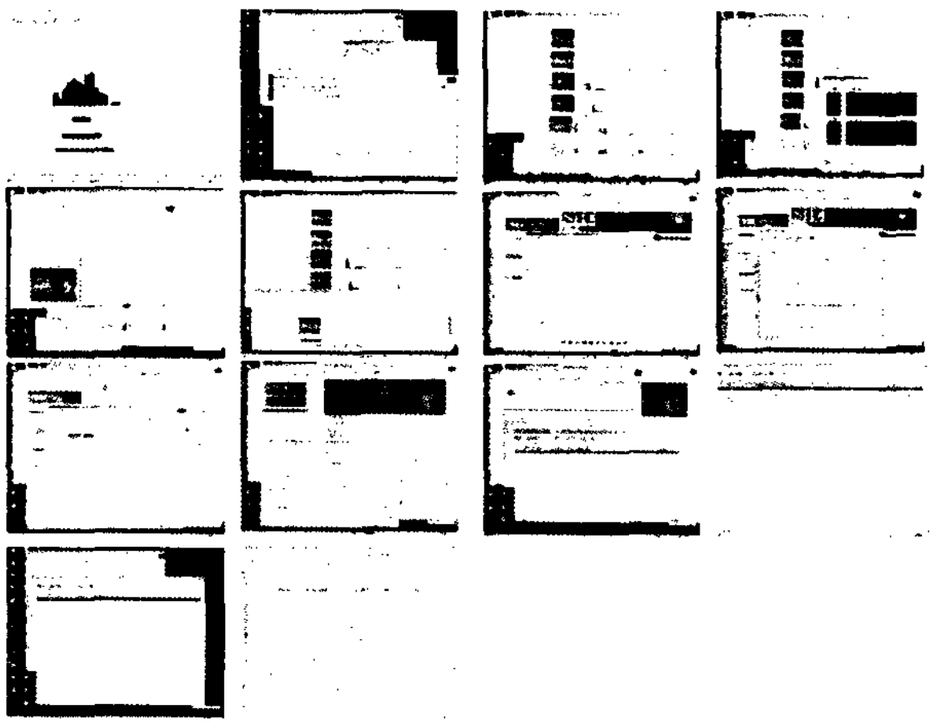
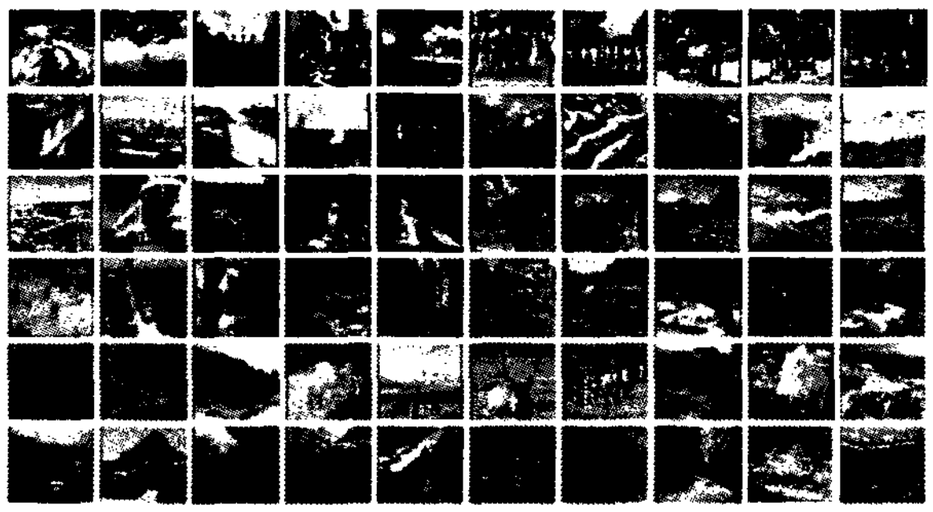


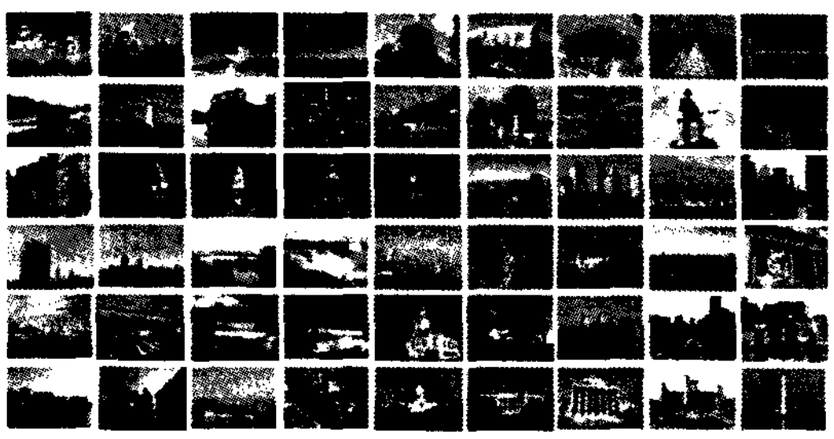
Figure 2: LOG-distributions of prediction error. (1H and R-G signals)



(3a) The image set "pc".



(3b) The image set "national park".



(3c) The image set "America".

Figure 3. Some sample images.

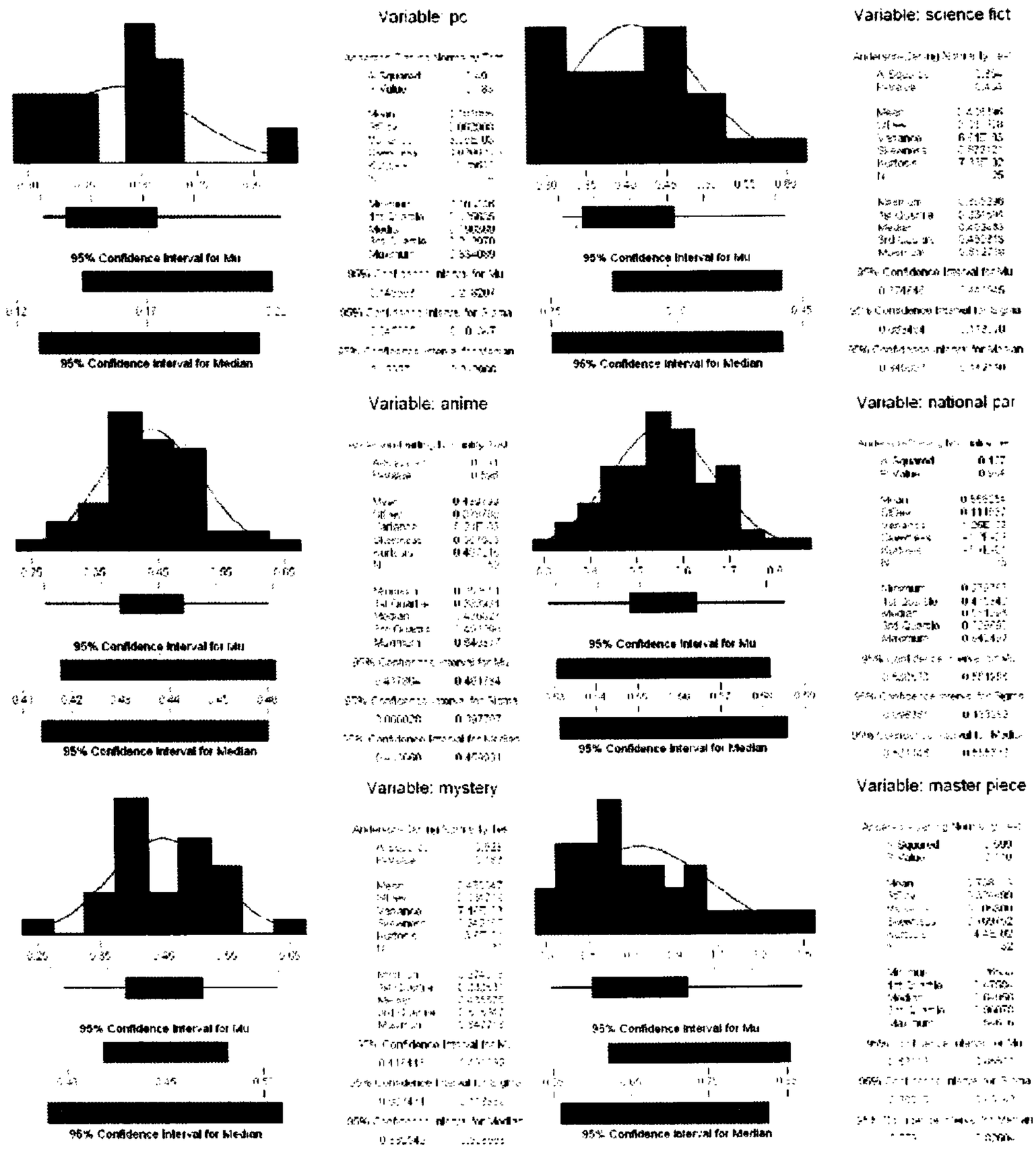


Figure 4. Performance analyses by the image sets.