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A two-stage parametric subspace model for efficient contrast-preserving decolorization

Key words: Color-to-gray conversion; Subspace modeling; Two-order polynomial model; Gradient correlation similarity; Discrete searching.

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Motivation

- All the existing contrast-preserving decolorization methods suffer from two shortcomings: lack of robustness and high computational cost.
- To alleviate existing difficulties, researchers have revisited the simple and conventional rgb2gray model. This model assumes that the grayscale output g is a constrained linear combination of the R, G, and B channels of the color image I.
- Many recent methods (e.g., RTCP, Gcs) based on the rgb2gray model have achieve impressive performance.

Main idea

- Extend the parametric discrete searching technique from the linear model to a two-order multivariance polynomial model.
- Obtain the solution space of a linear parametric model and divide the whole space into three subspaces, then， Gcs measures are used to obtain an immediate image from the first subspace (i.e., the linear parametric model).
- Based on the immediate image, we select the final image by using the Gcs measures again to determine the parameter weights in the second subspace.

Method

1. To extend the rgb2gray model to a two-order multivariance polynomial model, TPS assume that grayscale g is a second-order multivariate polynomial function for mapping.
2. Discuss the important of the three subspace and compare the similarities of the three subspaces.
3. Since the first subspace is the utmost important and another two subspaces similarly related, we apply a two-step approach to decolorization.
4. A measure is applied to the first subspace to obtain the immediate grayed image and applied again to select the optimal result from the immediate grayed image plus the second subspace-induced candidate images.

Major results

- For both Cadik's dataset and CSDD dataset, TPS outperforms the other approaches at almost all different threshold levels.

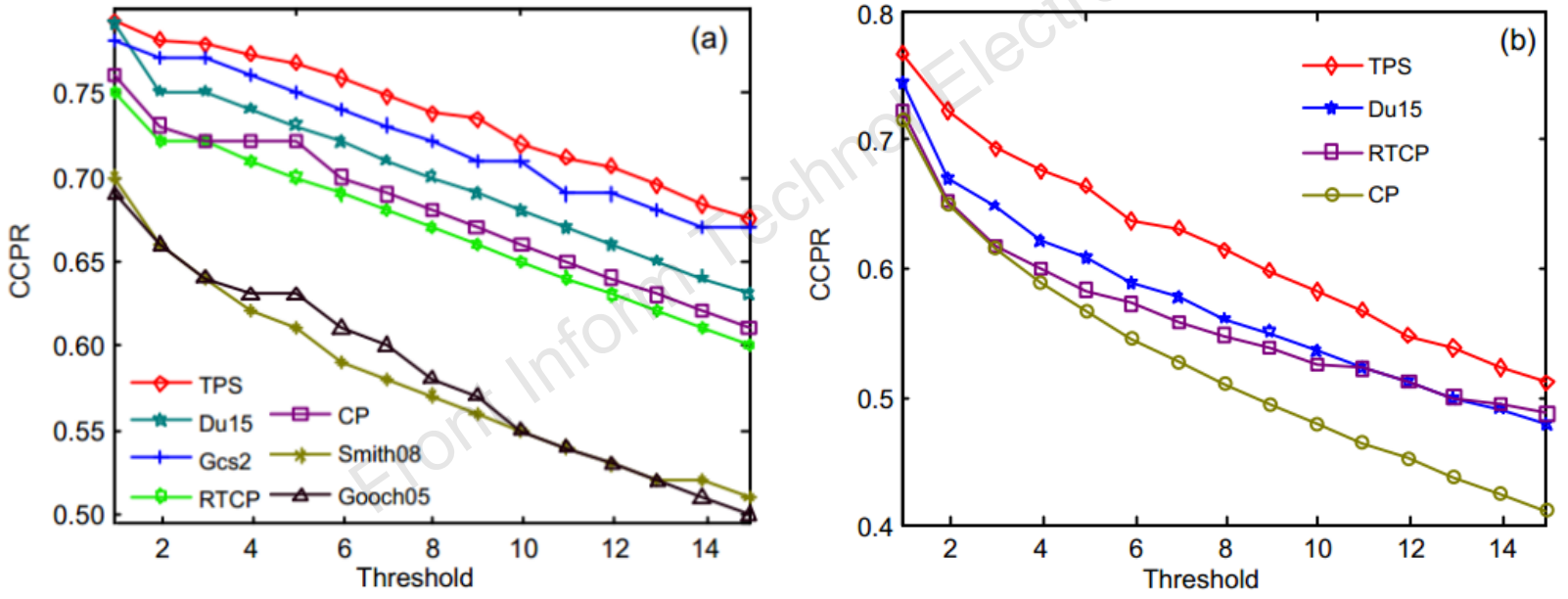

Fig. Comparison of the color contrast preserving ratios (CCPR) obtained by state-of-the-art methods using Ĉadík 's dataset (a) and the CSDD dataset (b).

Major results

- Although TPS is slower than RTCP and Gcs2, it still acheves a favorable performance in terms of both accuracy and efficiency.

Table Computational cost evalutions of different methods

Method	Runtime (s)	Method	Runtime (s)
Ancuti	1.547	RTCP	0.054
Kim	0.685	Gcs2	0.051
CP	2.045	TPS	0.143

A 550×717 color image was used as an input. TPS: two-stage parametric subspace; CP: contrast preserving; RTCP: real-time CP

Conclusions

- A two-stage color-to-gray conversion model employing a discrete searching strategy with gradient correlation similarity measures can enhance both the performance and computational efficiency.
- A comparative study using a wide variety of images indicated that TPS provides perceptually more plausible results than most recent algorithms.
- Experimental results show the advantages of TPS in terms of quantitative evaluation, qualitative evaluation, and algorithm complexity.