

Does Color Really Matter? Evaluation via Object Classification

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Motivation and Approach

Color is important, but how important?

- B&W tv works, people understand it.
- Would being a monochromat affect object recognition?
- How does being a dichromat affect object recognition?

Possible Psychophysical Approach

Conduct psychophysical experiments with human subjects in a large number of situations to see how colour affects performance.

Our Approach

Measure how the accuracy of deep-learning-based, object-classification methods is affected when:

1. monochromatic (i.e., CIE Y) images are used;
2. dichromatic (i.e., LS) images are used;
3. illumination-induced color changes are included.

Method Details

- The test and training images are from CIFAR dataset [4]
 - 60,000 images in 100 classes.
 - 50,000 for training and 10,000 for testing
- CIFAR nominally in non-linear sRGB format
 - Convert to linear sRGB [3]
 - Convert sRGB to XYZ
 - Convert XYZ to LMS via HPE matrix [1]
- Illumination variation added to images
 - Random von Kries scaling of RGB
 - Linearly interpolated across image

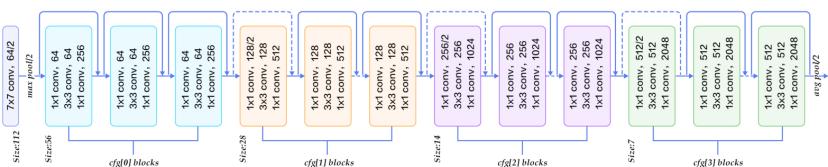


Figure 1. The ResNet [2] architecture schema. ResNet won the ImageNet 2016 and Microsoft COCO competitions. We used ResNet-50 with the configuration of blocks being 3, 4, 6, and 3, respectively.

Comparative Classifications



Tiger ✓ Snow Leopard ✗

Colour classification correct as 'tiger'; grayscale as 'snow leopard.' A case where the colour of the object is clearly crucial to identifying it.



worn fence ✓ wreck ✗

Colour appears to be important in interpreting the occlusion relationships and three-dimensional structure.



Wall Clock ✓

Stove ✗

Colour is important both in figure-ground separation (i.e., clocks from the wall versus multiple stove burners) and in making the hands of the clock visible.



tricycle ✓

Accordion ✗

The classifier has interpreted the shadows as keys of an accordion. This points to the usefulness of colour in interpreting lighting effects and in creating a greater sense of three dimensionality.



tennis ball. ✗ volleyball ✓

In this case, the fluorescent green that is typical of many tennis balls may have misled the trichromatic classifier.



television ✗

book jacket ✓

Colour helps separate figure from ground, but in this case incorrectly. (CIC reviewer objected to 'book jacket' classification. One could debate it, but it's not our classification, it's from CIFAR)

Experiment

Datasets:

- CIFAR: 50k for training and 10k for testing
- COCO: 41k images for validation (i.e., tuning)

Simulated variation in illumination colour across image

- Example →



Misclassification Percentage Error Rates (10,000 Test Images)

	LMS	LS	Y
Train & Test without Illumination Variation	28.8	33.1	35.0
Test with Varying Illumination—Train without	52.4	51.4	48.0
Train and Test with varying illumination	31.3	33.0	35.0

Conclusions

- Color is important, but not essential, for object classification
- Colour makes results more sensitive to illumination colour variation
- With varying illumination only 12% increase in error for b/w v.s. colour → 35.0 (Y) versus 31.3 (LMS)
- Dichromatic classification only 5% worse than trichromatic → 33.0 (LS) versus 31.3 (LMS)

References

1. Fairchild, Mark D. (2005). *Color Appearance Models* (2E ed.). Wiley Interscience. ISBN 0-470-01916-1.
2. He, Kaiming, et al. "Deep residual learning for image recognition." Proceedings of the IEEE conference on computer vision and pattern recognition, 2016.
3. IEC 61966-2-1:1999 Multimedia systems and equipment - Colour measurement and management - Part 2-1: Colour management - Default RGB colour space - sRGB, International Electrotechnical Commission, 1999.
4. Krizhevsky, Alex. "Learning multiple layers of features from tiny images." M.Sc. Thesis, Univ. of Toronto, 2009.

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