

# Does Color Really Matter? Evaluation via Object Classification

Brian Funt and Ligeng Zhu

Simon Fraser University

## 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

## Network Architecture

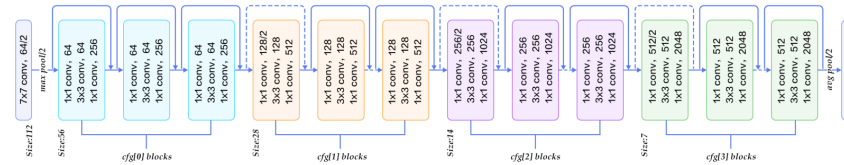
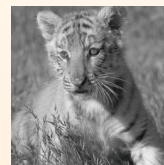


Figure 1. The ResNet [2] architecture schema. ResNet won the ImageNet 2016 and Microsoft COCO competitions. We used ResNet-50 with the configuration of blocks being 3, 4, 6, and 3, respectively.

## Comparative Classifications

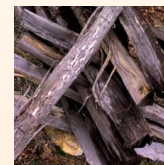


Tiger ✓

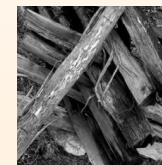


Snow Leopard ✗

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 ✓

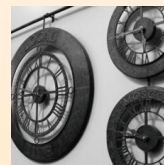


wreck ✗

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.



tennis ball. ✗

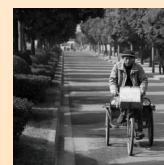


volleyball ✓

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



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.



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 978-0-470-01218-1.
2. He, Kaiyang, 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.

## Contact

Brian Funt: [funt@sfu.ca](mailto:funt@sfu.ca)  
Ligeng Zhu: [lyken\\_zhu@sfu.ca](mailto:lyken_zhu@sfu.ca)