BIOLOGICALLY PLAUSIBLE COLOUR NAMING MODEL

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MOTIVATION

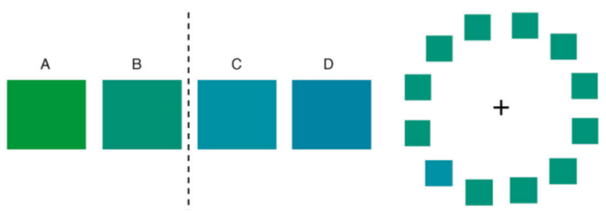
- Colour is construction of brain and our experience of the world is colourful.
- Infinite possible combinations of wavelengths produce metameric colours.
- Our brain reduces this complex world into cognitively tractable entities.
- Eleven colour categories are believed to be universal across languages [1].
- Colour categorisation offers a wide range of computational applications.
- There are very few $3D$ models of categorisation in the literature.

CONTRIBUTION

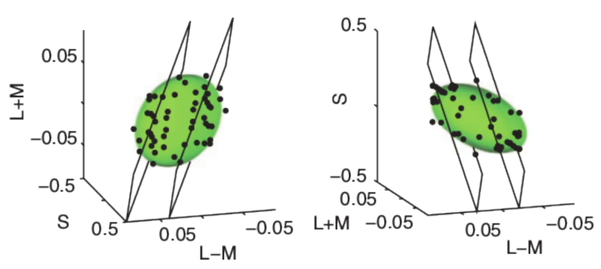
1. Modelling colour categories through a parsimonious set of ellipsoids in a $3D$ colour-opponent space.
2. Adapt ellipsoids based on image contents, i.e. axes and centres are not fixed.
3. Simple geometrical operations can be implemented by visual cortex neurons.

BACKGROUND

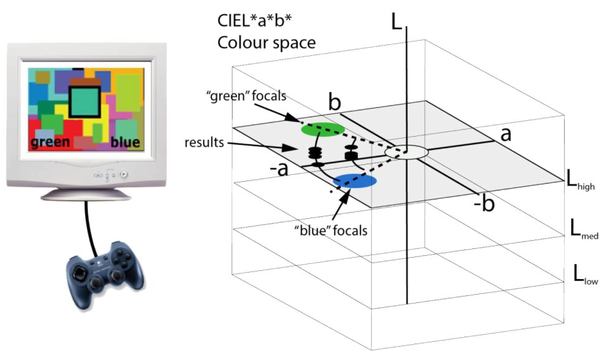
Studies of non-verbal categorisation suggest an intermediate free-from-language colour perception state [2].



A recent study [4] suggests many V1 and V2 neurons are isoresponsive to stimuli belonging to the surface of an ellipsoid in LGN-opponent colour space.



Our psychophysical measurements of colour frontiers [5], in which subjects chose the midpoint between two focal colours, resemble such shape as well.



SOURCE CODE

The source code is available at `https://github.com/ArashAkbarinia/ColourCategorisation`

ACKNOWLEDGEMENT

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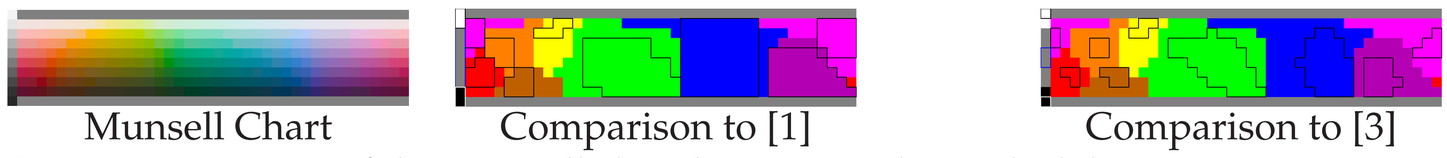
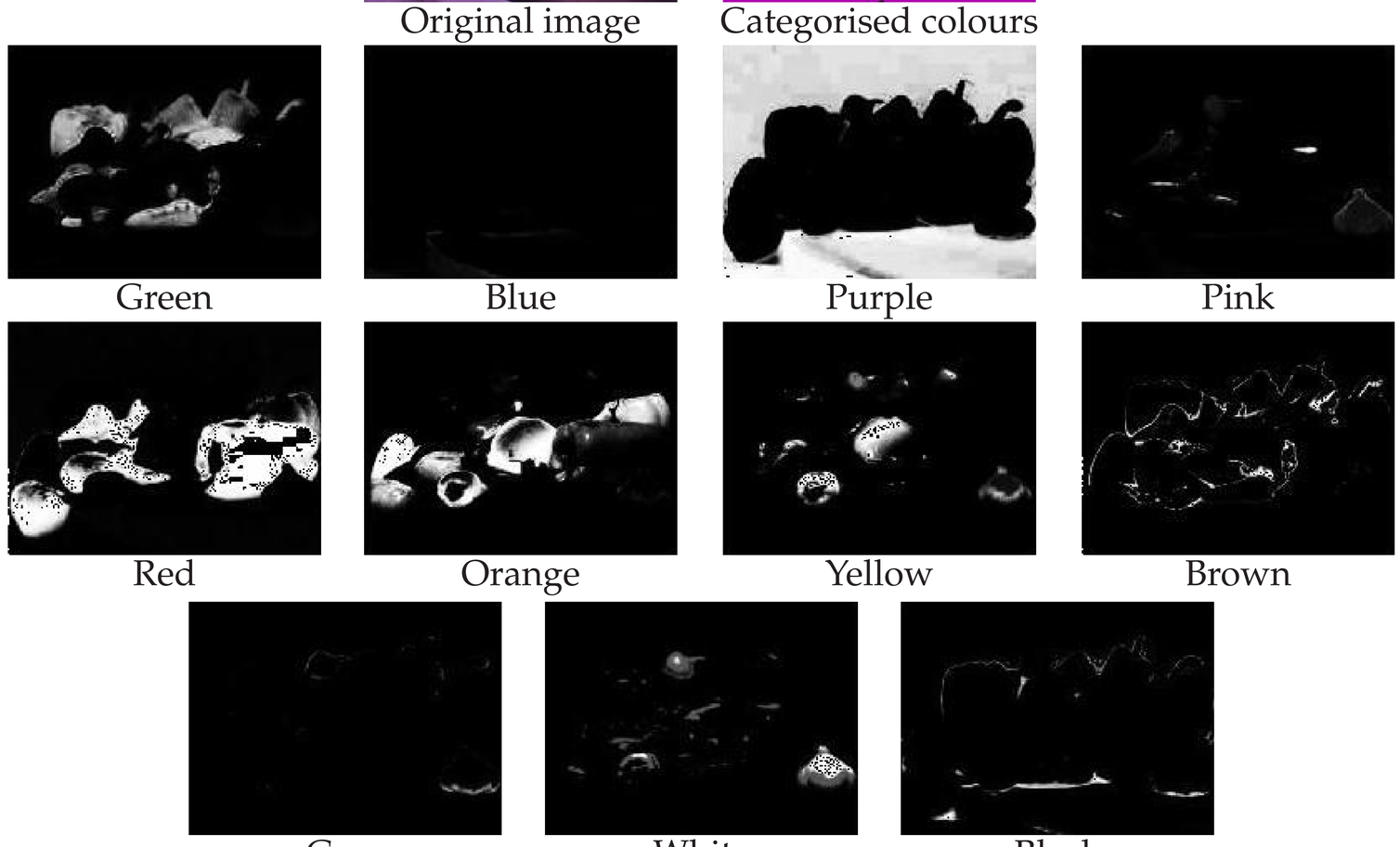
RESULTS



Munsell Chart — Comparison to [1] — Comparison to [3]

Our categorisation of the Munsell chart by max pooling. Black lines represent ground truth.

Original image — Categorised colours



Green — Blue — Purple — Pink

Red — Orange — Yellow — Brown

Grey — White — Black

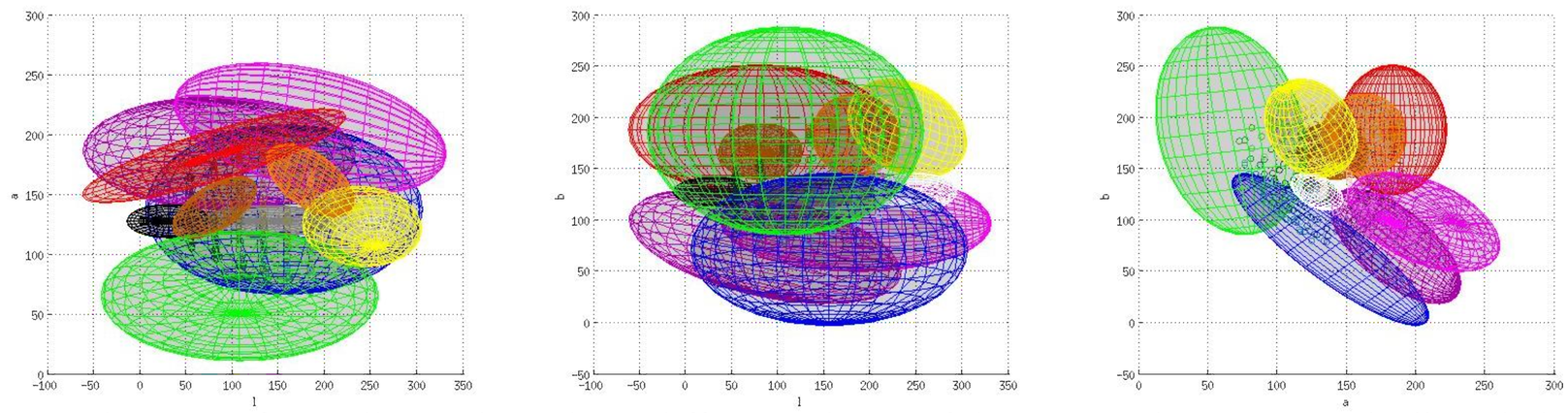
METHOD

Step 1 Colour Ellipsoids Fitting.

1. Obtain the likelihood of pixels belonging to each colour category.
2. Initialise ellipsoid $\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}=1$, where the semi-axes are a, b, and c. Rotation angles are θ, ϕ, and γ.
3. Minimise the probability error by modifying ellipsoid parameters.

Step 2 Pixel Belonging Evaluation.

1. Find the intersection h of ellipsoid surface and the line between pixel x and ellipsoid centre c.
2. Calculate the belonging of a pixel to one colour category with a sigmoid function $P=\frac{1}{1+\exp(g\|x-c\|-\|c-h\|)}$, where g is the growth ratio.



Visualisation of our ellipsoids in three different planes of the *CIEL*a*b** space, i.e. *la*, *lb* and *ab*.

FUTURE WORK

- Introducing colour induction.
- Interrelation with colour constancy.
- Adding intermediate colours, e.g. cyan, skin and olive.

REFERENCES

[1] B. Berlin and P. Kay. Basic Color Terms: their Universality and Evolution. University of California Press, 1969.
[2] T. Indow, Multidimensional studies of Munsell color solid, Psych. Rev. 1988.
[3] J. Sturges and T. Whitfield. Locating basic colours in the Munsell space, Color Res. Appl. 20, 1995.
[4] G. Horwitz, C. Hass. Nonlinear analysis of macaque V1 color tuning reveals cardinal directions for cortical color processing. J. Nature neuroscience, 2012.
[5] C. A. Parraga, I. Rafegas. Colour categorization from colour opponency, Perception 42 ECVP Abstract Supplement, page 109, 2013.