Multiple Camera Fuzzy Colour Classification

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Colour classification vision systems face difficulty when a scene contains both very bright and dark regions. An indistinguishable colour at one camera exposure may be recognisable at another. Two methods are proposed which combine to aid the classification of colours in scenes with very high dynamic ranges.

Using a pie-slice colour classifier with both a normalised red/green colour space and a unique normalised cyan/magenta colour space aims to provide reliable colour classification.

Fuzzy Colour Contrast Fusion will assist the colour classification, enhancing or degrading red, green and blue channels of input images. Combined with a multiple camera automatic exposure system, colours are to be classified using 'worst case' lighting conditions.

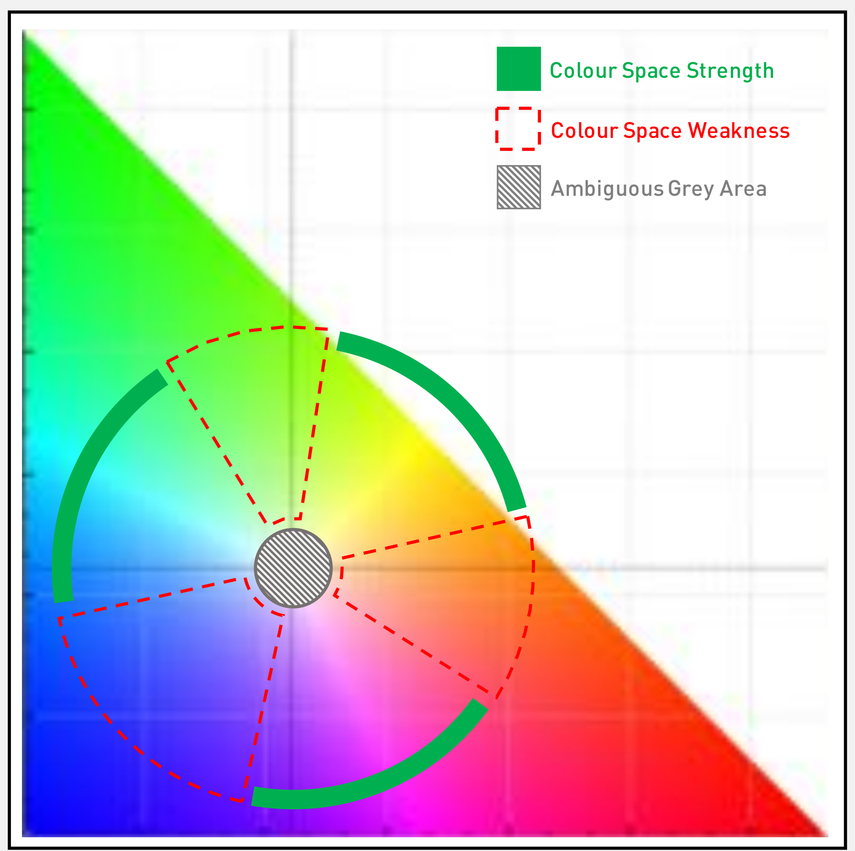
The system may then adapt for any combination of lighting conditions, provided they are within the trained dynamic range.

Isomorphic transformations are used to focus each camera on a planar surface, while further transformations ensure scale and alignment match between the three input images. Classification data is to be saved into lookup tables per-camera, enabling conflicts to be resolved if two cameras classify disparate colours.

Interim results conclude that the normalised cyan/magenta colour space produces a stronger classification of certain colours, complimentary to the weaknesses of the red/green colour space.

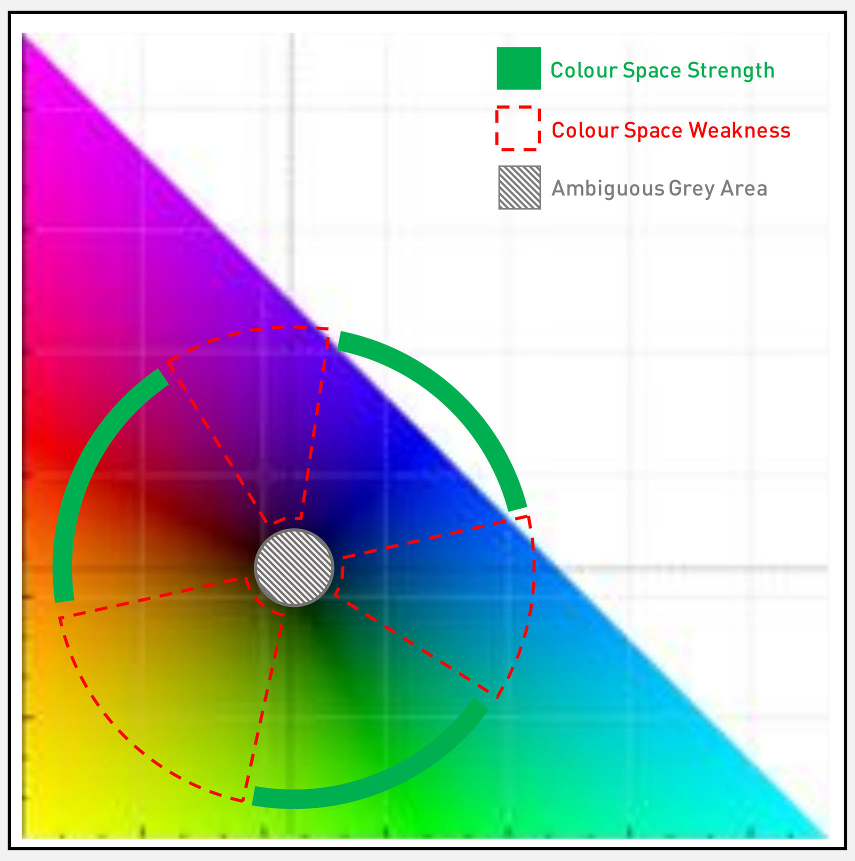
Further research will explore the complementary relationship between these colour spaces, resulting in the recommendation of a particular colour space for certain colours.

Normalised Red/Green Colour Space



This colour space excels at classifying colours found within the marked ranges. Outside these areas a colour may be still classified, however similar colours may pose difficulty. In the 'weakness' areas, the relationship between hue and angle is not as strong, creating 'wider' classifications.

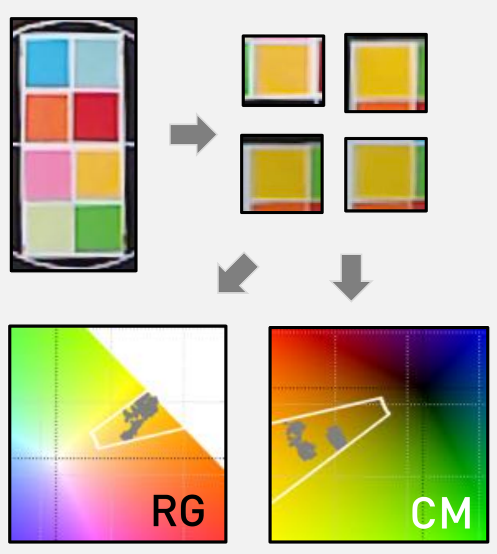
Normalised Cyan/Magenta Colour Space



This colour space complements the normalised red/green colour space. The best space for each colour will be used as a classification heuristic and to increase speed. By using two colour spaces, the strongest classifier is generated for each colour.

Pie-Slice Colour Classification

The pie-slice classifier works with the selected colour spaces to sample and identify colours. The normalised red/green or cyan/magenta hue value represents the angle of the 'slice', while the saturation of the colour is represented by the radius.



Yellow Colour Patches (left) plotted on RG (lower left) and CM (lower right) colour spaces.
Note the Red/Green colour space bunches together, generating a stronger classifier.

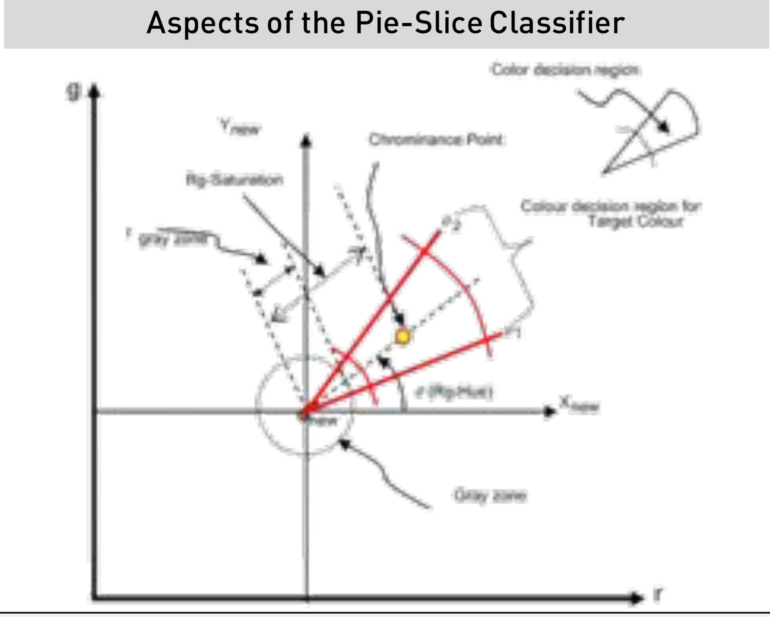
Formulae for Red/Green colour space generation

$$r = R/(R+G+B) \qquad g = G/(R+G+B)$$

$$rg - Hue = \tan^{-1}\frac{(g-0.333)}{(r-0.333)}$$

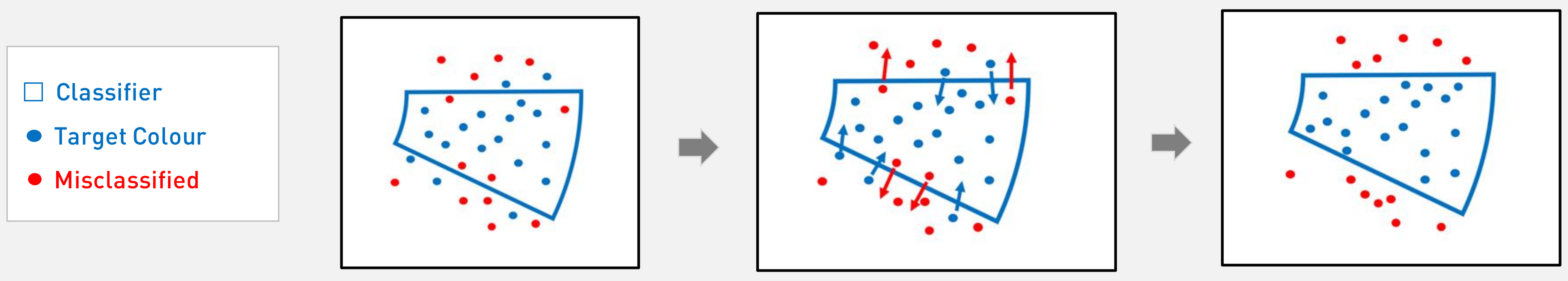
$$rg - Saturation = \sqrt{(r-0.333)^2 + (g-0.333)^2}$$

Aspects of the Pie-Slice Classifier



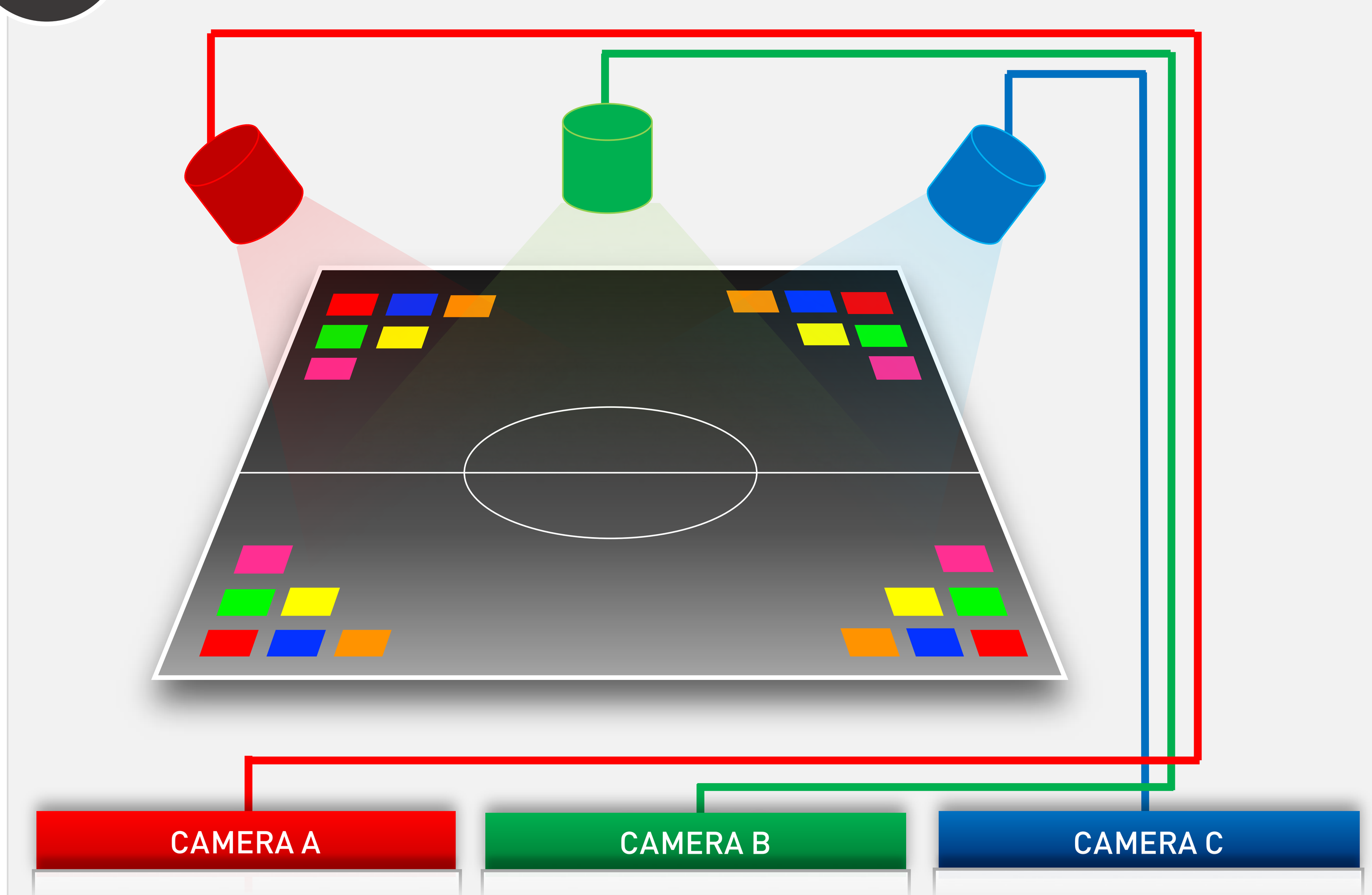
Fuzzy Colour Contrast Fusion

Fuzzy Colour Contrast Fusion (FCCF) works closely with the training process to minimise misclassifications. Misclassified pixels in known-areas are compared to correctly classified colours, in terms of red, green and blue values. Fuzzy Logic rules are then generated to adjust the input image to suit classification of that colour. This process results in both classifying previously misclassified colours and reducing false positives.

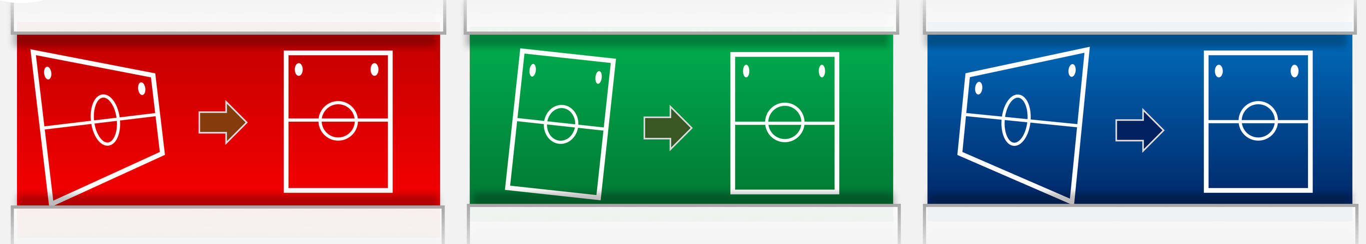


Once all pixels have been plotted in the colour space, FCCF is run per colour, per camera. This 'pushes' or 'pulls' pixels in or out of the pie slice classifier, separating similar colours. By running FCCF per colour, per camera, the process focuses the classification rules on creating three possible colour classifications per pixel. These results are passed onto the final colour classification step where the most 'confident' colour is chosen.

1 Camera Positioning



2 Camera Alignment



Homography warps the perspective of each camera input, removing both rotation and isometric deforms. Each camera is aligned using the circle Hough Transform, ensuring each colour patch is positioned in the same pixel region for each camera.

3 Camera Exposure Spread

Each camera is adjusted to match a different lighting aspect of the training scene. This ensures all colour patches can be sampled.

4 Fuzzy Colour Contrast Fusion

5 Colour Classification

IN GREY AREA "Too bright, no match"	CLASSIFIED AS: "Red"	IN GREY AREA "Too dark, no match"

The system would output the above values if assessing a pixel in moderate illumination. In bright illumination, Camera C would expect to classify a colour, while Camera A in a darker.

References

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Shin, H., & Reyes, N. H. (2010). Finding near optimum colour classifiers: Genetic algorithm-assisted fuzzy colour contrast fusion using variable colour depth. Memetic Computing, 2, 219–236. doi:10.1007/s12293-009-0025-8

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