Colour Detection in Objects using NIN Implemented CNN

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Abstract- In vision tasks like image retrieval, colour is one of the most essential properties used to characterise images. The process of recognizing the name of any colour is known as colour detection. The way we perceive and understand things is influenced by colour. It's much easier to be fed values without having to go through the trouble of locating someone who understands colours. This study proposes that a computer be taught to recognise and define colours accurately enough to be helpful. The polite way to extracting the concerns using CNN algorithms is presented in this study. The foundations of computer vision are used to track three different colours: red, green, and blue. Each colour value in a computer is defined as a number between 0 and 255. We use a dataset that includes RGB values along with their names. If we want to increase the precision of existing colour detection algorithms based on convolutional neural networks the properties of the attention mechanism are used to model colour priors in this paper. In order to increase the accuracy of the system, we also look at several colour detection models and compare them. The research also looks at how colour detection is used in real-world applications like object detection.
Keywords - Colour detection, Colour Detection Models, Image Processing, RGB value detection, Convolutional Neural Networks (CNN), Network in Network (NIN).

INTRODUCTION

The expanse of visual picture data has increased at an exponential rate during the last few decades. Visual picture information is one of the most common ways for people to interpret the world and receive external information since it is a pretty accurate and vivid portrayal of the objective reality. The process of determining the name of any colour is known as colour detection. It is self-evident that humans accomplish this behaviour spontaneously and without exerting any effort. In the case of computers, however, this is not the case. In order to interpret light into colour, the human eyes and brain work together. The signal is transmitted to the brain via light receptors in the eyes, which identifies the colour Humans have associated specific lights with their colour names since childhood, and this is not an exaggeration. In this project, the same method is effective for detecting colour names. The foundations of computer vision are used to track three different colours: red, green, and blue. When we run the code once it has been successfully compiled, a window appears with the image shown on itWe also retrieve the pixel's colour name, as well as the red, blue, and green values of three other colours. It has applications in colour identification and robotics. Proposed approach is also used in driverless cars, for example, to detect colours. This technology detects traffic and vehicle backlights and determines whether or not to stop, start, or continue driving. This can also be utilised in industry to pick and place different coloured things with the help of a robotic arm. A variety of image editing and sketching programmes provide colour detection as well.

Colour image processing is a two-dimensional format that is used to perform digital picture processing. The processing of digital photographs by a digital computer is known as digital image processing. Each pixel in a colour image contains image information. On a colour image, a pixel is a small unit of programmable colour. Raster maps or raster graphics images are used to store colour images in memory. The RGB (Red, Green, Blue) colour model is one of three main colour models used in image processing. This colour model is a standard concept for computer graphics systems and can be used in a variety of situations. Because the RGB colour components are highly correlated, many processing approaches focus solely on the image's intensity component. In colour displays, the RGB colour space is used. The intensity and chrominance of light are measured in a colour picture. Each pixel has three values. Images contain a lot of supplementary information that is utilised to make picture analysis easier. For instance, image extraction based on colour and object recognition. However, identifying vehicle colour in uncontrolled environments is a challenging task. The difficulties mainly stem from two aspects: 1) Certain colour types are very close to other colour types and, thus, are very hard to discriminate. For example, cyan is not so distinguishable from green in real-world images. 2) The colour of a vehicle is prone to be affected by numerous interference factors, such as haze, snow, rain, and illumination variation.

The main goal of this paper is:

- To introduce various aspects of colour recognition
- To review some recent and existing techniques.
- To provide a comparative study of existing techniques with their pros and cons.

Here we discuss various colour recognition techniques which are implemented and recently used for efficient colour tracking in the real world.

Problem Statement

Given a random picture, an application needs to be implemented which detects pre-defined colour on a pixel in real-time through the RGB approach and provides the ability for the handler to be able to detect the appropriate colour of the object perceived in an image file. It also allows such users to track colour and help people who are colour blind to detect colours precisely and accurately.

The following are the primary challenges that the object detection model faces:

- Uneven illumination, varied postures, vast sizes, mutual occlusion, and other factors can cause issues such as missed detection and false detection.
- When the algorithm is interfered with by a complex background, the algorithm's accuracy drops dramatically.

Formulation of Solution

The picture consists of many pixels. Every picture element corresponds to a code. The total of those codes provides a whole image. After analyzing the code, the code may be used for the definition of Colours, and therefore the Colours of those definitions are used for the picture element markers used to determine the Colours within the image.
To address the problems above we propose a CNN-based learning framework for the task of colour naming. In the first stage, we intend to pre-train a CNN model with generalizable feature extraction layers, which can preserve and concentrate the colour characteristics of images without the influence of noisy labels. For this purpose, we propose a self-supervised CNN model trained on image patches randomly selected from the training set, and use the colour histograms of patches as their own supervision. In the second stage, we fine-tune the CNN model with only the last layer retrained, on image patches labelled with the colour names.of images without the influence of noisy labels. For this purpose, we propose a self-supervised CNN model trained on image patches randomly selected from the training set, and use the colour histograms of patches as their own supervision. In the second stage, we fine-tune the CNN model with only the last layer retrained, on image patches labelled with the colour names.

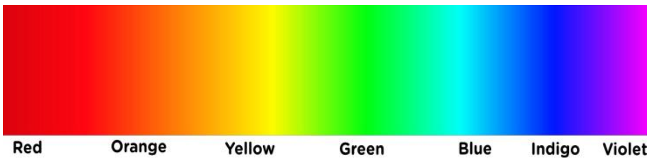

Fig 1. Colour Scale.

LITERATURE REVIEW

A review of numerous colour models is offered, along with their descriptions, comparisons, and evaluation results in our presented research work. On a specific hardware platform, these models are utilised to show different image components. A colour model's main objective is to provide colour parameters. The research shows that converting several models speeds up picture processing with the fewest time delays and provides invariance in the results of different models due to complex mathematical equations. These colour models can be used to speed up image processing using techniques like contrast limited adaptive histogram and contrast limited adaptive histogram equalisation. A common framework for computer graphics systems that is just not ideal for all of its purposes is the RGB colour model, which we use in our approach. Red, green, and blue colours are closely related to one another. Numerous earlier models have been investigated that recognise colours without employing CNN techniques and instead rely on image processing [2][4][8].

In their article, (Duth and Deepa) [1] discussed a technique for automatically choosing a threshold from a bar graph with grey levels derived using discriminant analysis. This answers the question of figuring out whether thresholds are useful right away. The discriminant criterion determines the best threshold (or collection of thresholds) by maximising the discriminating measure alphabetic character (Hongjiao) [10] provided a study that explains colour science concepts and methodologies. Recognizing the shade in the image is done using the RGB display. Red, green, and blue lights are combined in different ways to create a variety of hues in the RGB display, which is a shading model. (S. J. Lee and S. W. Kim) [11] mentioned the actual cases of filters and needs in his work. The concept of a lowest weighted median filter, or a taxonomic group that functions in the same way, is presented. In their publication (D. M. Filatov) [12] provided a research work that gives an effective solution to the problem of minimum error thresholding that falls below the concept of normally distributed gray values at the object and picture element level. This is true for multiple-threshold options (Chen, Li and You) [6] describe Image segmentation, which divides a picture into its constituent regions or objects, in their paper Digital Image Process. The complexity of the segmentation needed depends on the issue at hand. Non-trivial picture segmentation is one of the most challenging issues in image processing. In their work, (Liu, Wang, and Zhao) [13] also go through how to comprehend the basics of OpenCV, how to use the K-Means algorithm to extract colours from photos, and how to filter photos based on the RGB values of the colours. This opens the door for a plethora of new uses, such as looking for specific colours in a search query or finding clothes that matches them. Many research also utilize Support Vector Machines (SVM) to process the dataset in order to improve accuracy of results. [3][6][21]. Since there are specific applications where the objects of interest are significantly distinct due to their high saturation in one of the RGB colour components, one issue that has emerged in image studies is related to the detection and segmentation of landmarks with high colour intensity, primarily related to primary colours and their augments, which are used in the definition of colour spaces [25][26][27].

In studies of [14][24] AlexNet is the fundamental and classical network for classification. While it can be considered as a mixed descriptor of image global and local features. Five deep network convolutional layers and two fully connected layers make up the seven layers that make up an AlexNet. We used AlexNet as a baseline in our experiment because many models today are constructed using the Alexnet structure.

Google later announced GoogleNet in 2014. The network structure used by GoogleNet is more complex and comprises 22 levels. The number of parameters is only comparatively less than that of AlexNet, however the accuracy is greater. The neural network's strength is increased by GoogleNet using NIN (introduced later) [15][24]. GoogleNet employs numerous "Inception" techniques to address this issue because merely increasing the network topology may result in overfitting and the usage of computational resources. Numerous studies on vehicle-based colour identification also exist, and these studies are remarkably similar to the one we conducted on object-based colour detection. [16][17][18][[20][21].

S.No	Year	Paper Name	Methods	Dataset	Result
1	2021	Colour Detection of RGB Images Using Python and OpenCV [4]	RGB colour model, image processing, OpenCV	CSV files dataset consisting of random images (labelled dataset)	Identification of monochrome colours in images.
2	2015	Vehicle Colour Recognition With Spatial Pyramid Deep Learning [3]	CNN, Spatial Pyramids (SP), SVM, RGB model	Images of vehicles, license plate etc.	Eliminates necessity of pre-processing and gives readily application oriented results.
3	2016	Recent Advances in Colour Object Recognition: A Review [5]	Study of RGB, CMY, HSV colour detection models and shape-based detection	Images and Videos used in previous models.	Solves visual spectrum problems and integrates geometric shape recognition approaches.
4	2021	Computer Vision for Colour Detection [2]	RGB, CMYK, HSL colour models, OpenCV, image processing	Camera fed dataset	79 %to 97% varied accuracy for colour detection.
5	2020	Vehicle Type and Colour Classification and Detection for Amber and Silver Alert Emergencies Using Machine Learning [6]	CNN, YOLO, Support Vector Machine(SVM)	15,601 images of vehicles of different colour and models.	Integration of shape based and colour based models using CNN.

6	2021	Object Detection Combining CNN and Adaptive Colour Prior Features [7]	CNN, colour prior model, object detection	PASCAL VOC dataset consisting of 9963 images and 24,640 labelled objects	Cognitive driven colour model emphasising colour pattern approach.
7	2017	Different Colour Detection in an RGB Image [8]	RGB model, Image Processing, MATLAB.	Images of random objects available from open sources	Labelled dataset and Matlab features reduces response rate time.
8	2015	Comparative Study On Colour Recognition Methods [9]	RGB, YCbCr, Rg-Chromaticity, HSV	FGPA based camera images taken from videos.	Comparative analysis of different colour models.

Table 1– Related Research Work Study

Comparision Study

A suitable way for representing the colour signal is required to use colour as a visual cue in multimedia, image processing, graphics, and computer vision applications. "In addition to other disciplines, there is literature on colour models in physics, engineering, computer science, and artificial intelligence. Compared to a greyscale image, a digital image in colour can store and provide more information. Through the use of spectroscopes and filters, digital acquisition devices (such as scanners and cameras) may divide light beams into the three basic colours red, blue, and green. In order to record a colour, we need at least three parameters to do so (for example, red, blue, and green). We employ the colour model to express colour information in digital photos. The colour models must be three-dimensional since a colour is described by three parameters. The models display a point in three-dimensional space that is assigned to a certain colour using mathematical functions. The following are some examples of colour models:

1. **RGB colour model**

Figure below depicts the three primary hues (red, green, and blue) and their combinations in the visible light spectrum. "Different colours could be represented by the combination of the different weights (R, G, and B). By averaging the R, G, and B values, we may obtain the colour cube (Fig.2). The values of the grey levels are represented by the color schemes on the diagonal line between the origin and the cube's coordinates (1, 1, 1) [13]. When the RGB model is used, each colour can be represented by a coordinate system with values ranging from 0 to 100 percent for each of the main RGB colours. (or from 0 to 255 brightness levels, for example) [7]. The adaptive skin colour model is built up using R colour and normalised RG colours (r, g) because (r, g, R) is less susceptible to changes in light source and ideal for real-world applications [39]. The RGB colour model is the industry standard for computer graphics systems, although it isn't ideal for all of them." The colour components of red, green, and blue are highly connected.

$$I = \frac{1}{3}(R+G+B).$$

$$H = COS^{-1}\left\{\frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{\frac{1}{2}}}\right\}$$

$$S = 1-\frac{3}{(R+G+B)}[\min(R,G,B)].$$

Fig 2. RGB Cube

2. **HSI colour model:**

The HSI model is introduced to enhance the RGB model. The Hue Saturation Intensity (HSI) colour model closely mimics how colours are detected by human vision. In comparison to other colour models, the method for converting from RGB to HSI or vice versa is more complicated [22]. The letters I, H, and S stand for intensity of light, hue, and saturation, respectively (the degree of a colour permeated the white colour). A colour is categorised as low white when its saturation level is high. The relationship between HSI and RGB is as follows: When replicating how the human eye perceives colour, the HSI model is more accurate. Since the hue (H) parameter is more consistent under different lighting conditions, it is selected as the system's main parameter. The range of the second parameter saturation threshold (S) is modified according to the brightness value (I) and run-length coding techniques are used in the image fusion process, based on the idea that the apple of a human eye has different reflections in different illumination, in order to improve the accuracy of identification in various lighting conditions.

3. **RG-chromaticity model**

R, G, and B are ratios of a single tristimulus value to the total of the three tristimulus values. A neutral object assumes that stimuli with red, green, and blue values are equal. There can only be one neutral location when the three coordinates are equal since rg lacks luminance information. The white point of the rg chromaticity is made up of a third red, a third green, and a final third blue.

We've gone over a number of colour identification methods provided by various writers. All of the methods have the same goal of detecting colour in an image, but the methodology are distinct.

WORKING

Approach for our Proposed Model

Our model works on CNN based approach that integrates a Network in Network approach in it. There are two steps to our strategy. We initially train the SS-CNN model to recognise generic colour properties, then fine-tune it for our purpose in the second stage.

Training Self-supervised CNN Model –

In this stage, we train the SS-CNN model using a newly built training set made up of randomly selected picture patches from the prior training set. According to the author, "We selected the colour histogram as the supervisor for the self-supervised learning structure because it depicts the posterior probability of distinct colours in an image patch and so provides useful guidance for the network to distinguish between them." In this study, we adjust the softmax loss function to take into account the new supervision information and employ a cluster-based colour histogram to more clearly describe unique hues.

We do not employ the widely used colour histogram technique, which divides the colour space evenly, because the spatial distribution of colours in RGB space is not equal. "While some colours, like black and grey, may occupy incredibly small areas and are too close to one another to be easily differentiated, others are the complete opposite. The first step is to create a K-means cluster on the entire training set of pixels, with each pixel represented by its RGB values. Then, using the cluster centres as a codebook, the colour histogram of a certain image patch is created by classifying each of its pixels into the relevant cluster. Then, in order to make the dominant colours stand out while weakening the other colours, we intensify the colour histogram by exponentiating each element. The supervised label vector for the image patch is then created by normalising the sharpened colour histogram. The possibility that an image patch will be attributed to the associated cluster class can be represented by each element in the label vector.

Finetuning with Classic CNN Structure - To target the colour names suggested by [19], we finetune the pre-trained SS-CNN model as well as a sample selection strategy based on the attributes provided by the SS-CNN model. " Similar to how standard CNN models are built, the model is trained with all feature extraction layers kept and just the final fully linked layer retrained.

Considering the pre-trained SS-CNN model is designated as Net-1, we refine it using the training patches we acquired before while also giving them labels with the colour names of their parental images. The newly developed model, represented by Net2, is definitely impacted by the incorrectly labelled samples. Therefore, in the next stages, we employ sample selection to get rid of some of the noisy data that harms our model. To improve the performance of our model, sample selection and fine-tuning procedures can be repeated repeatedly.

Implementing Network in Network –

Network in Network (NIN) is a network structure that can improve the discriminability of the model. Traditional convolutional layers scan the input using linear filters and a nonlinear activation function. To abstract the data, NIN uses more intricate structures (micro neural networks). By stacking several of the previously mentioned structure, deep NIN may be constructed. We are able to use average global pooling over extracted features in the classification layer, which is simpler to understand and less prone to overfitting than conventional fully connected layers, thanks to increased local modelling via the micro network.

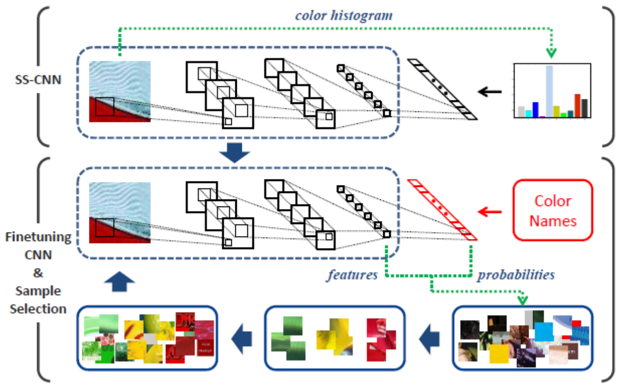

Fig 3. CNN framework for dataset

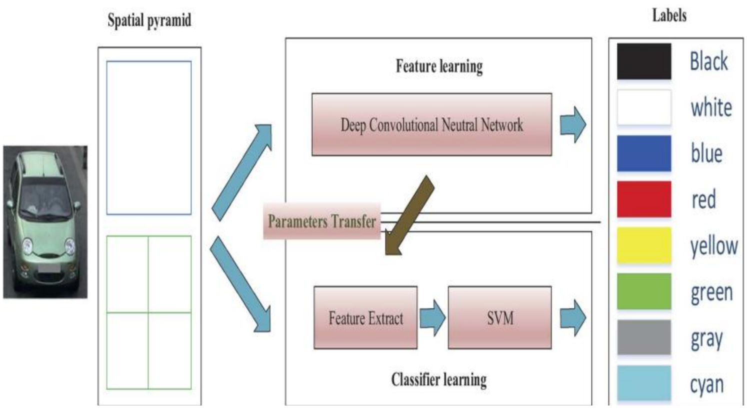

Fig 4. Conceptual CNN Architecture for proposed model.

Experiment Result

In our approach we train three models using CNN that is NIN-oriented. On the basis of earlier models that operate on Alexnet, Googlenet, and Colornet, respectively, comparative analysis is conducted. M2 follows the structure of Alexnet, while M3 follows Googlenet. As an eight-layer network with NIN as an addition method, M4 is known as Colornet. The depth and extent of the network are what separate M3 and M4. M4 has a great deal less layers than M3. M4 can save a significant amount of computation time and resources while providing almost the same performance, and its model is smaller.

The additional test data is used to test M5. The additional data set contains incorrectly labelled images, so we used some of it to fine-tune our model before testing it again with the remaining images. The results showed a considerable improvement in performance. Due to M1's poor performance and middling accuracy, we did not test it on every colour.

Method	**Red**	**Green**	**Blue**	**White**	**Black**	**Gray**	**Yellow**	**Cyan**	**Average**
M1	-	-	-	-	-	-	-	-	0.7880
M2	0.9615	0.9455	0.9810	0.9286	0.9495	0.9535	0.9583	0.9394	0.9522
M3	0.9846	0.9636	0.9857	0.9847	0.9220	0.9651	0.9444	0.9091	0.9574
M4	0.8864	0.8465	0.9227	0.9618	0.9094	0.3874	0.9829	0.7801	0.8347
M5	0.9938	0.8797	0.9761	0.9456	0.9355	0.8490	0.9622	0.9858	0.9410

Table 2 - Colour recognition performance on image dataset on different models.

Colour	**RGB**	**HSV**
Yellow	**0.9794**	0.9450
White	**0.9666**	0.9624
Blue	0.9410	**0.9576**
Cyan	0.9645	**0.9716**
Red	**0.9897**	0.9866
Gray	**0.8608**	0.8503
Black	**0.9738**	0.9703
Green	**0.8257**	0.8215
Average	0.9447	0.9372

Table – Accuracy of model in different colour spaces.

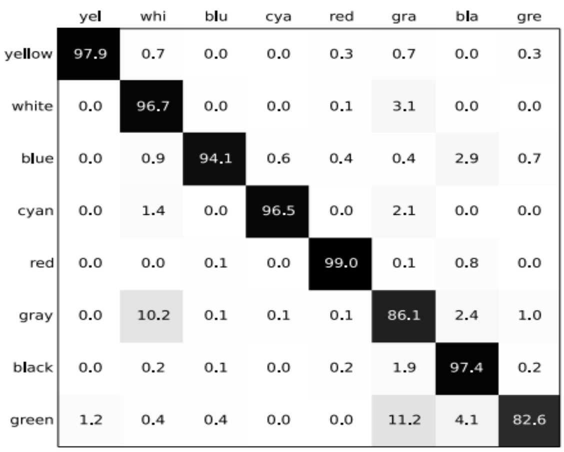

Fig- Confusion matrix from our model with RGB colour space.

CONCLUSION

In this research work we used NIN based CNN approach to detect colours in an object In the initial analysis, we developed a technique to extract the necessary colour field from an RGB image. This method's main benefit is that it explains how to employ certain colour picture models to execute image processing while being able to colour discriminate a monochrome image on those models. Colors are a powerful descriptor that are used to identify things and make extraction from a scene easier. Humans can perceive thousands of different colour shades and intensities. The colour models are made using colour components and colour recognition. The study's findings show how to combine several models in a way that minimises time delays while speeding up image processing. Unsolved issues in computer vision include colour object recognition. Both visual and geometric qualities serve to represent the colour item. To improve recognition accuracy, a variety of strategies have been tested. The HSV colour space is thought to be more trustworthy for precise colour recognition. Convolutional neural networks are shown to be noise-free and resilient to changes in the natural environment.

Our model successfully capturing object colours in very high accuracy of 94,47% outperforming many previous models. We also determine that different colour models can be beneficial in different circumstances depending on illumination conditions. Hence a comparative study of different colour models is also successfully implemented. Future work can be done to make the fusion of the visual and geometric object properties for automatic object identification in real time. This concept can also be implanted in multiple upcoming real world application such as Intelligent Transport System for traffic light detection, image processing concepts etc.

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