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A NOVEL METHOD FOR COMPUTER VISION TASK AND COLOUR ANALYSIS FOR MULTI-LABEL PIXEL CLASSIFICATION

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ABSTRACT

In computer vision tasks involving colour images, it is imperative to classify pixels based on their colour and segment the corresponding sections. The main challenges in developing methods for precisely classifying pixels in accordance with colour are the variations in digital representation, linguistic theory, and human colour perception. With a novel mechanism that combines mathematical analysis, colour wheel, fuzzy colour triangle, and multiple label group, our solution seeks to address these problems. This method yields accurate descriptions of all detected colours and allows pixels to be automatically classified into 12 standard colour categories. Based on colour theory and statistics, the method provides a trustworthy, unsupervised, and impartial method of choosing colours. The proposed "Reduced-ABSCCA (AB Space for colour Classification and Analysis)" model was evaluated by conducting the several experiments. It provides 98% of accurate colour naming and segmentation and can be support several computer vision tasks.

Index Terms- Colour image analysis, colour models, colour image segmentation, pixel classification, fuzzy colour theory.

INTRODUCTION

There have been several experiments performed in history to address the challenges associated with the representation and analysis of colour. Different methods have been used to represent colour, such as the conventional colour triangle and, in the era of computer vision, colour spaces like RGB and CIELAB.

In computer vision task colour plays a vital role. Colour analysis is crucial part to an extensive range of industries, including city planning, medical, satellite imaging, food quality assessment, and visual scene description. Due to the complexity of colour, the absence of distinct limits or transitions, the bias in human vision, the influence of background, and the syntactic difference between computer colour representation and subjective human perception, colour analysis is still a difficult task despite its significance.

The computer vision tasks that addresses the various difficulties associated with colour analysis and representation of colour. A colour vision algorithm recognizes the colours contained in a image and assign a colour name or term to each, just as a human perception. The system should also be able to identify these colour names within a digital colour space and utilize these subspaces for precise image segmentation and colour classification.

The way that humans perceive colour varies depending on their environment, context, upbringing, and lighting [5,6]. This is the primary cause of issues with colour vision. In addition, human perception is impacted by the phenomena known as colour constancy, which describes how, unlike computers which, detector colour difference at the pixel level, human brains perceive colour uniformly on surfaces regardless of potential changes in lighting or reflections of stronger hues. As a result, developing a computer technique that can replicate the countless ways in which colour might be experienced is not feasible. The fact that there are regional variations in how people see colour contributes to the second issue: colour names are not globally recognized. The human name some terms "crimson" and "cherry" which can refer to the identical hue of red. In fact, humans, give complex terms like greenish-blue, pinkish-red, whenever there is a mixing of colours [1].

Several solutions have been proposed to overcome these challenges and develop precise computer vision techniques for colour identification and categorization. Two main areas are the focus of contemporary colour analysis research: two steps: (1) colour segmentation; (2) colour naming and detection. Research on colour naming and detection seeks to map the subjective character of human perception of colour onto a computer colour representation and human understanding for colour. This is a challenging undertaking [8]. Fuzzy models, on the other hand, are better at handling the hazy borders between hues and can bridge the semantic divide in addition to excelling in colour segmentation [1]. Colour quantization is an additional method for colour segmentation that relies on clustering; nevertheless, its application is restricted due to trained data.

We present ABSCCA (AB Space for Colour Classification and Analysis) in this paper. The aforementioned drawbacks are addressed by the innovative method of colour identification, labelling, and segmentation known as ABSCCA, which also offers more precise colour analysis. The suggested approach builds an effective model that can carry out the above tasks automatically using fuzzy logic principles, colour wheel, and multi-label systems, making it appropriate for real-world application.

Our method's salient features are as follows: Its foundation is the colour theory. It eliminates colour vision and makes the analysis reliable and repeatable; it integrates fuzzy logic sets to approximate colour labelling and understanding, reduce the semantic gap; and finally, it is simple to use, automatic, non-supervised. It easily performs the partitioning the pixels based on colours and gives colour description for colour analysis. Finally, ABSCCA enables the user to alter the obtained output to suit the particular application. This is made feasible by ABSCCA's user-friendly interface and superior graphical display of the identified colours.

RELATED WORK

Literature Survey

The colour theory describes how people see colour, which is a function of how light is received in, replicated back, and sent by the things in our environment. Some wavelengths of light are absorbed and others are reflected when an object is struck by light; it is through by reflection that we can see an object's colour. However, each human has a unique set of cultural and environmental associations with colour, which affects how we perceive it. The colour wheel was designed by sir Issac newton in the year of 1704. It contains primary colours of red, yellow, blue then secondary colours of green, orange, violet, and 6 tertiary colours and brown which was taken as deep orange in colour wheel.

The Munsell tree, developed in 1913 by H. Munsell, is the most significant. Hue, Value, and Chromaticity are the three uniform dimensions that the distribution of colours is basic tenet of the Munsell tree. An uneven cylindrical space was created by deciding where to position the colours based on monitoring people's reactions. Wider chroma ranges for certain hues are made possible by the un-uniform space in the Munsell chart. In soil science and psychology, this system is the most commonly utilized.

Practical alternatives such as fuzzy models are being employed, which address the infamously ill-defined borders between hues. Fuzzy set is more akin to the human thought process of colour classification than are crisp colour partitions. Consequently, a number of studies have employed for fuzzy logic to effectively establish a correlation between human perception, colour language, and computational colour representation.

Colour quantization is a commonly used technique for colour segmentation, in accordance with fuzzy colour models. The foundation of colour space quantization is clustering, typically achieved through colour thresholding or closest neighbor classification. In a group of predefined colour classes, nearest neighbor classification determines the k-means neighbors to a given pixel. This approach is constrained by the need to define the boundaries and clusters, which is dependent solely on the training data, but some recent research yields more reliable results.

Digital colour models were developed in response to the growing use of computers in order to better accommodate these new activities. Digital colour spaces: HSL/HSV, CIELAB, and RGB are the three main ones. For digital and graphical applications, RGB was developed in 1996. Three coordinates, which stand for “red, green, and blue” values, are used to represent colours in this space. Even though RGB is the colour space most frequently utilized in digital era, the colours in it can represented are constrained, device-specific, and inconsistent with human visualization. HSL/HSV spaces, on the other hand, were created in a circular fashion in order to better match how colour is perceived by humans. These spaces are made up of a three directional cylinder that transforms the RGB to a polar coordinate, they are called as “hue, saturation, and value” (in HSV) or “lightness” (in HSL).

METHODOLOGY

We tackled the colour analysis problem in two parts to develop the suggested solution. First, by studying the colour wheel and obtaining the pure colour bases in the colour space provided by CIELAB through the application of colour theory and elementary geometry ideas, we are able to address the issues of automatic recognition of colours and segmentation. This phase is known as "generating geometric knowledge". The second step is "Formation of fuzzy colour space and colour labelling," involved identifying and describing the recognized colours using fuzzy logic concepts, colour theory, and multilabel classification.

1. Generating Geometric Knowledge

Creating a more straightforward hue space for colour identification and categorization was the goal of this step. We decided to use the CIELAB colour space for our work. For the input colour image, we, locating the pure hues on the colour wheel precisely within the CIELAB colour space. We might work in the simplified AB two-dimensional space and ignore the luminance dimension in the colour space. The AB two-dimensional histogram, which displays the locations of the sharp hues, was computed. Radiating outward from a central point was the resulting linear distribution. Endpoints and branches that followed a circular path were produced by skeletonizing the double histogram. Owing to their characteristics, based on the pure colours could be represented by the lines that connect each endpoint and the dual histogram's centre.

Angle bisectors allowed us to acquire precise colour regions, which were then organized into ten groups based on colour perception, form, CIELAB construction. They are Green, yellow, pale orange, teal, bright orange, purple, red, ultramarine, pink and blue.

The brown and the other neutral colours: white, black, and Gray are not entirely chromatic. The pure colours are dispersed radially and are found distant from the centre in the CIELAB colour space. Then, all variations on these colours progressively approach the centre, with the non-pure colours which are get into a gradient parallel to the Luminance axis and the shades having a lower brightness than the tints. The neutral colours are white, black and grey were positioned in the middle of our restricted AB space. The brown was situated in the middle, surrounded by the pure colour regions. In this manner our model ABSCCA gives 12 colour categories.

A. Generating Geometric Knowledge and B. Formalization of Fuzzy Colour Space and Colour Labelling:

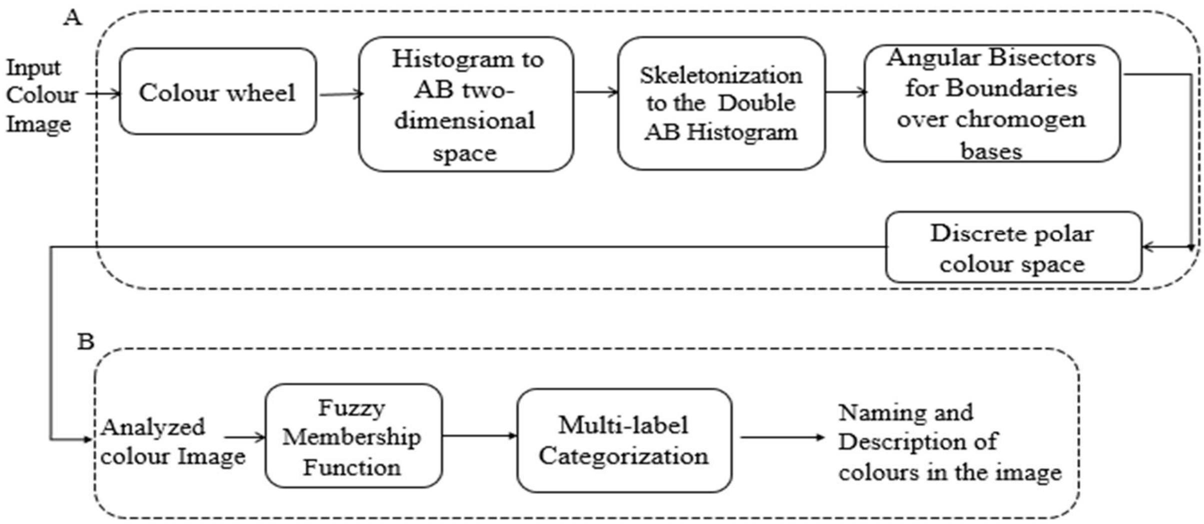


Figure 1: The block diagram of the ABSCCA. It is processed in two steps of first step: A. Geometric Analysis for colour labelling and colour categorization. Second step B. Fuzzy space for description of the colours in the multi-label pixel environment

2. Formalization of Fuzzy Colour Space and Colour Labelling

In this step, we introduced fuzzy model concepts to multi-labelling systems in order to construct an impartial uninterrupted space for colour labelling and classification. Specifically, we employed trapezoidal membership function to describe fuzzy colours [5,6]. In order to preserve continuity, simplify the issue, and align with the mathematical angular analysis, we taken a set of membership functions from polar coordinates and trapezoidal polynomials.

Each colour class's linear piecewise functions were computed for the angle membership, yielding the results are 1 for angles that fell within the centre of the class, 0.5 for angles beyond the limits, and 0 for angles that were above the peak of the subsequent or preceding colour class.

In trapezoidal membership function we use two functions i.e., radius and angle. then radius membership which is used to distinguish the pure colours, neutral and brown. the functions of neutral colours are defined by. With the following definition of the Critical neutral Radius (r1), We categorized all hues as neutral colours if their radii were less than r1. It was determined, however, that the membership function would provide 0.5 for both brown and pure colours at the Critical brown Radius (r2). The original Critical brown Radius (r2) was separated by 5 points, giving rise to two new points: the Modified Critical brown Radius (r2 0) and the Critical hue Radius (r 3).

Comparison of the models:

The proposed model ABSCCA is more accurate and unbiased as compared to the other model of Colour Vision Algorithm. As we seen in earlier section that the colour vision model gives output based on the human observation which is not suites the digital colour vision tasks. It leads to complication of computing the results in computer The remaining colour models was not perfectly describe the colours, shades and mixing of colours in a colour image. in our model, for particular theta and radius it describes the colour and its shades and other mixed colour in it.

However, the ABSCCA supports the digital computer vision tasks for the Digital Colour Image processing and it describe the colours not only based on human visualization but also as per the digital colour representation. It also classifies the pixels of colour image into 12 colour names with their description, it was the major advantage of our model as compare to the existing colour models.

RESULTS AND DISCUSSION

The ABSCCA provides the computable and qualitative results for colour labelling and colour categorization as well as segmentation of the pixels. in the digital world colour plays a important role mainly in the computer vision task. Achieving consistent and trustworthy results using colour measuring devices can be challenging because of variables including sample size, substrate colour, and illumination.

Furthermore, colour is rarely regarded as a stand-alone concept in most applications; this distinction, combined with the difficulties associated with human visualization, background, and understanding, leads to a lack of sufficient analysis metrics and ground truth data for analyzing the colour as a stand-alone concept. The multi-colour input image is taken to obtain computable results for our model ABSCCA.

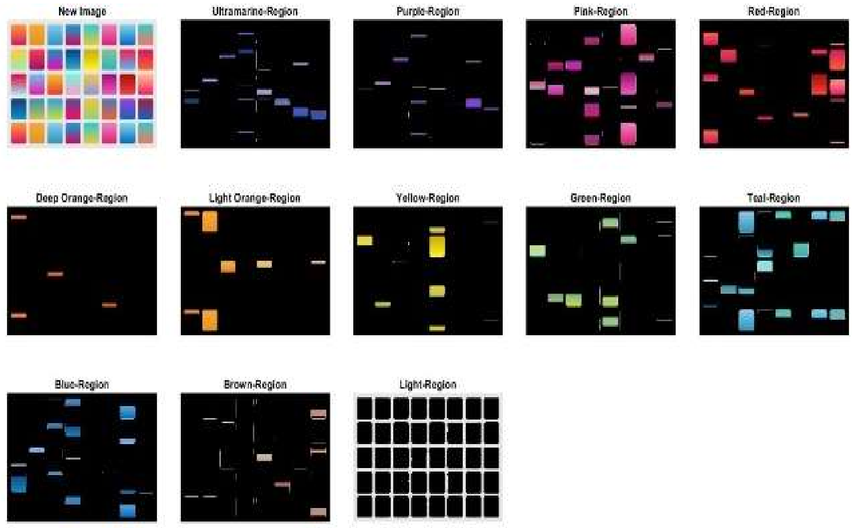


Figure 2: The 12 colour categories of the multi-colour image to understand the computable results of the ABSCCA

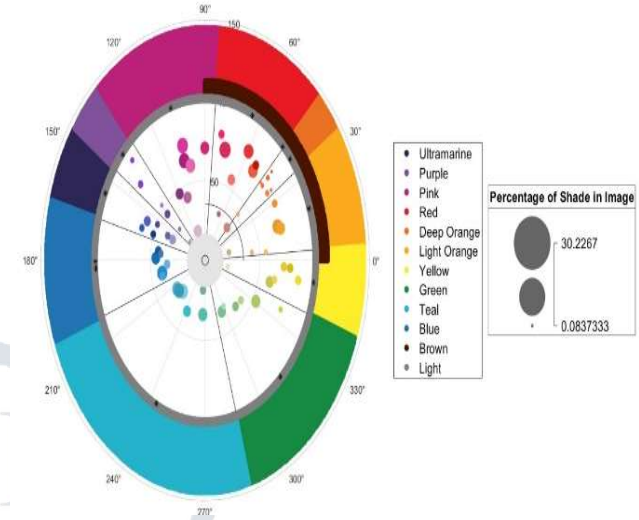


Figure 3: The polar graphical representation of the input image.

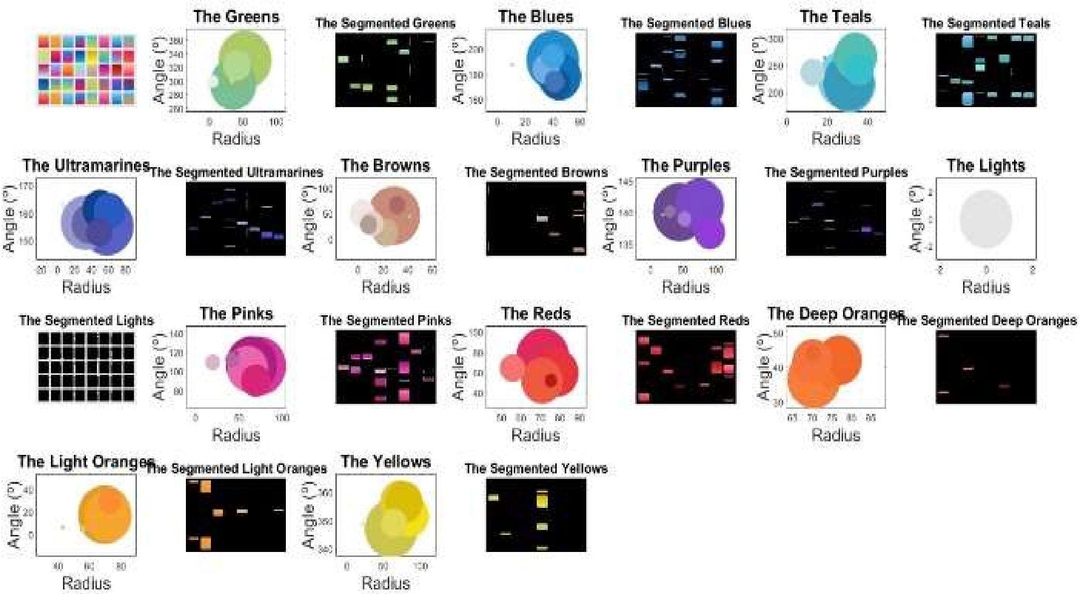
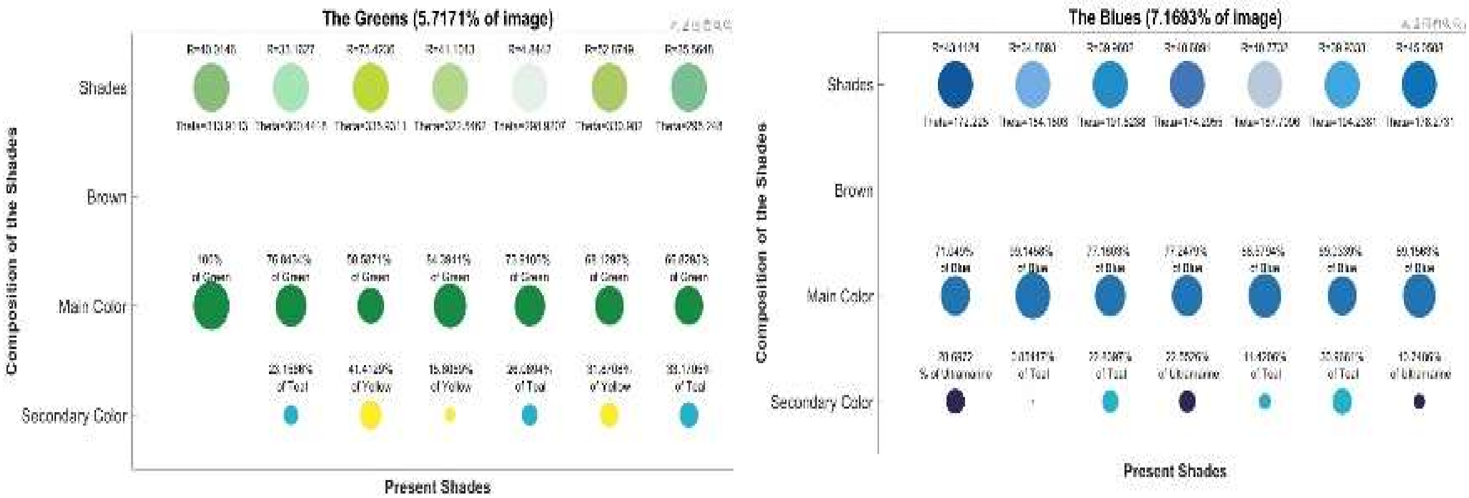
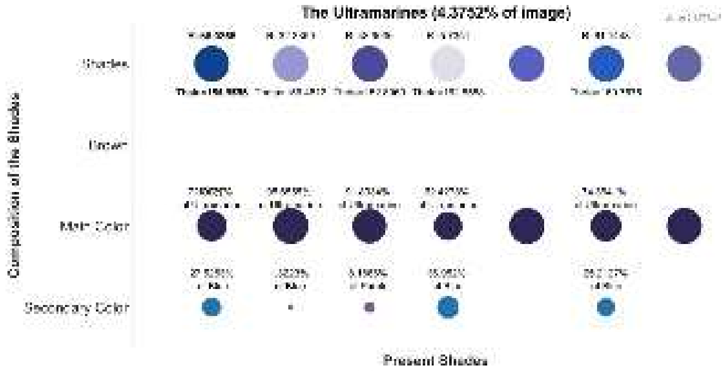


Figure 4: The radius and angular representation of each 12 colours of the image.

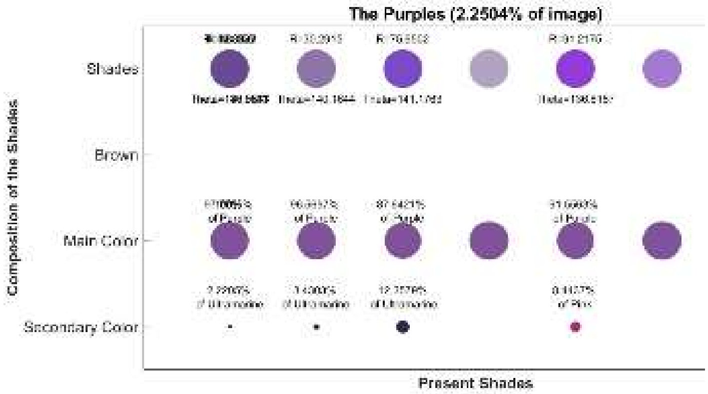


(a)

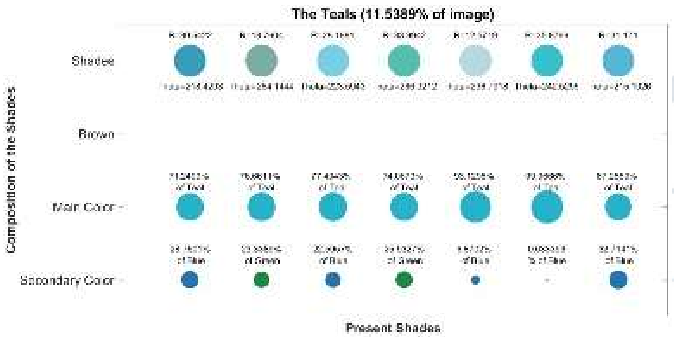
(b)



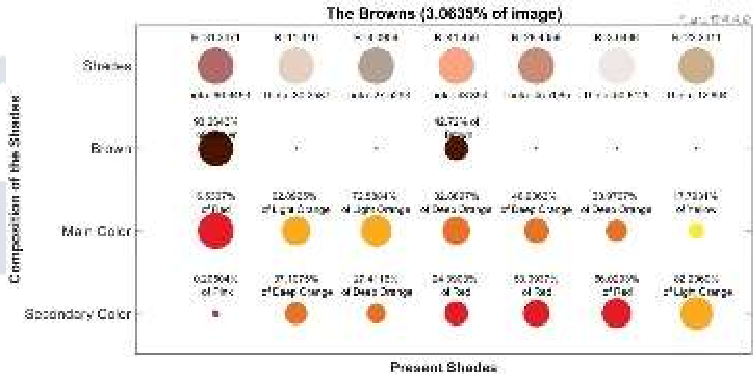
(c)



(d)

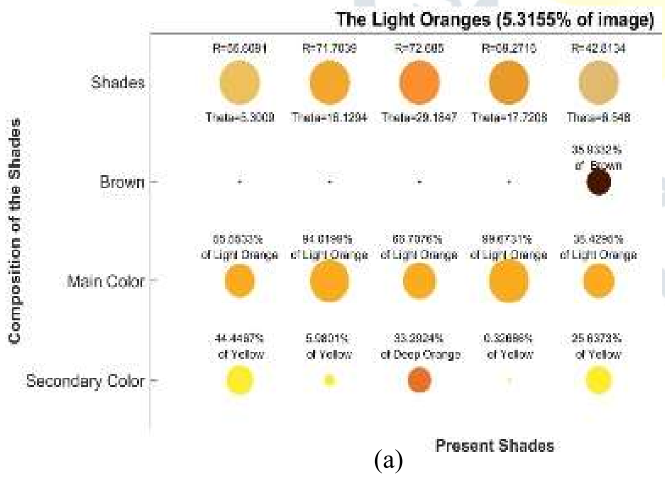


(e)

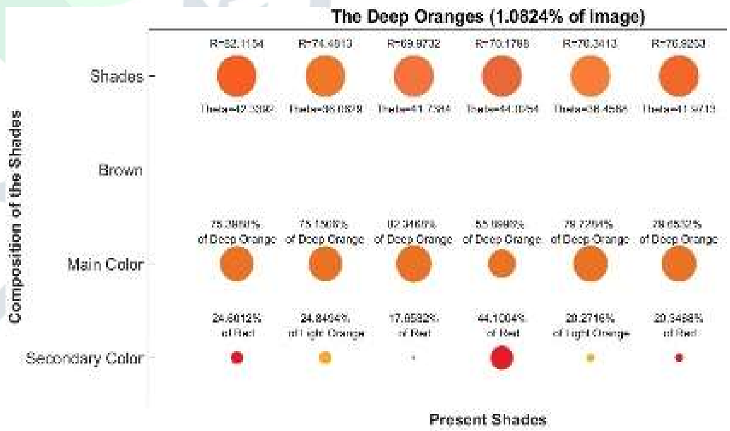


(f)

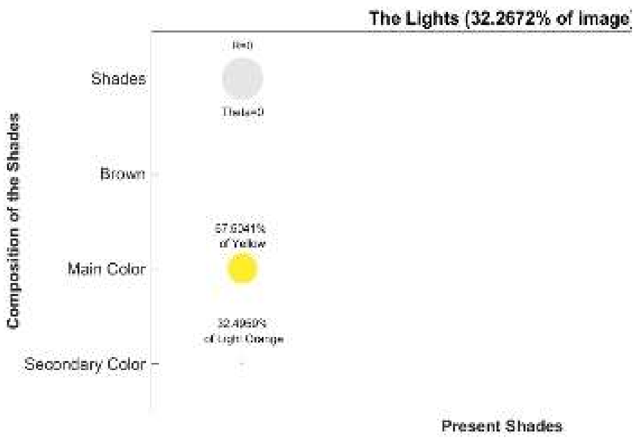
Figure 5 : The results (a), (b), (c), (d), (e), (f) represnts the percentage of green, blue, ultramarine, purple, teal and brown colours and their corresponding shades present in the input image.



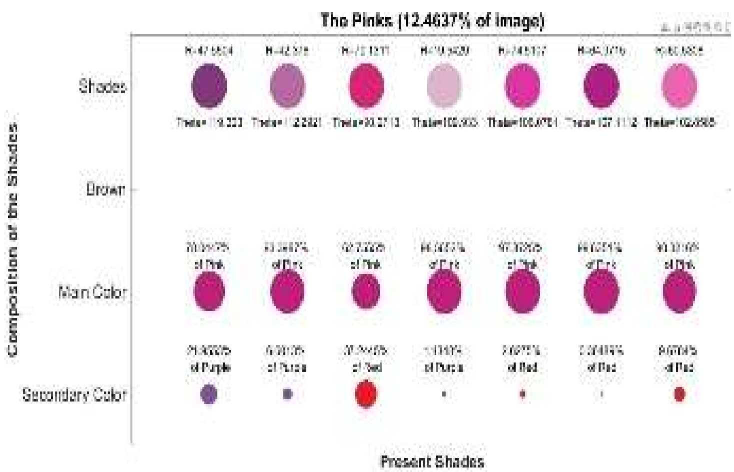
(a)



(b)



(c)



(d)

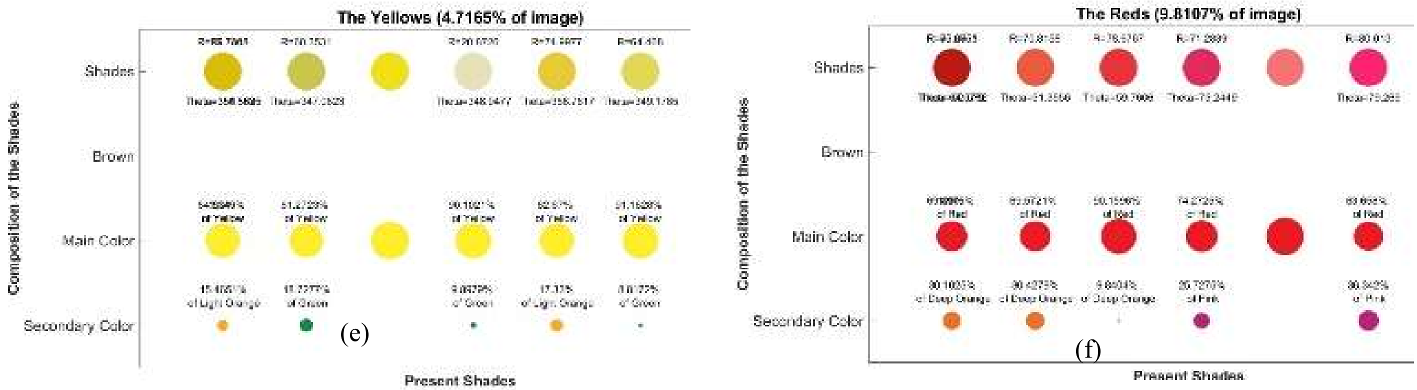


Figure 6: The results (a), (b), (c), (d), (e), (f) represnts the percentage of light orange, deep orange, lights(neutral), purple, yellow and red colours and their corresponding shades present in the input image.

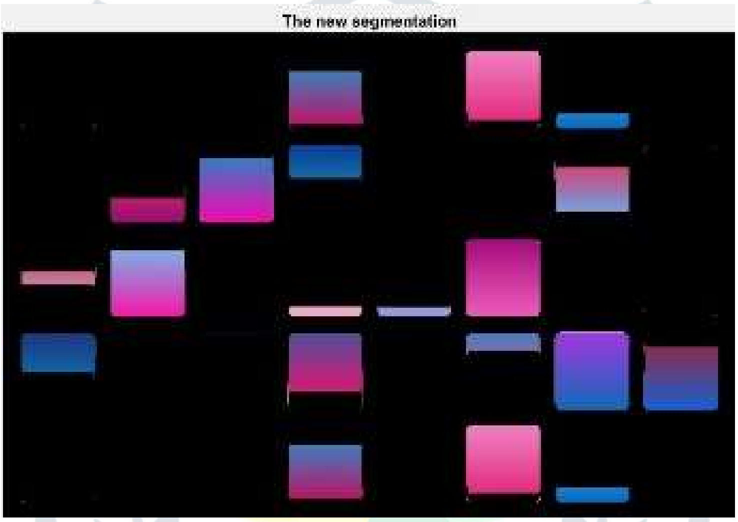


Figure 7: The newly segmented image of the multi-colour input image.

The proposed method ABSCCA is applicable to the real time applications, it includes the satellite imaging, product quality analysis and also in digital image processing. To analyze the qualitative performance of the ABSCCA to the real time application we choose a real time colour images and evaluated them through our method. So, the clear analysis is given in the below figures.

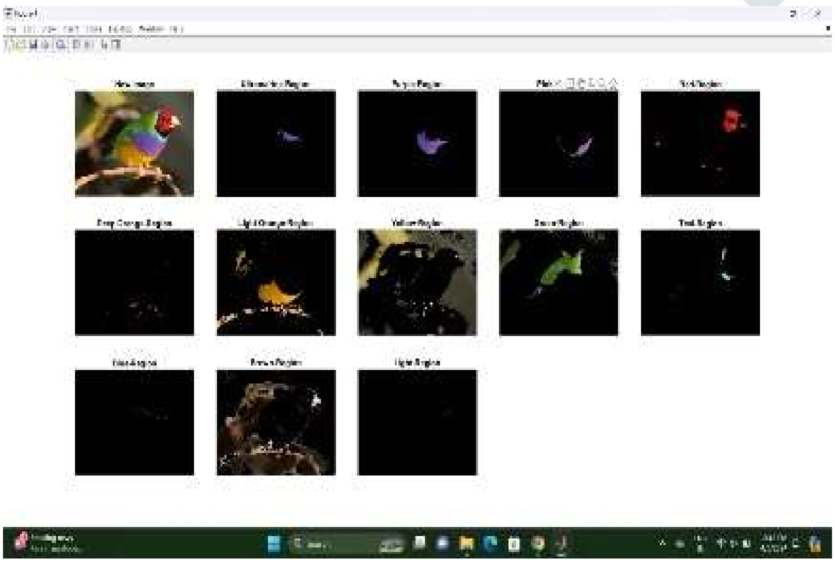


Figure 8: The 12 colour categories of the real time bird image to understand the qualitative results of the ABSCCA

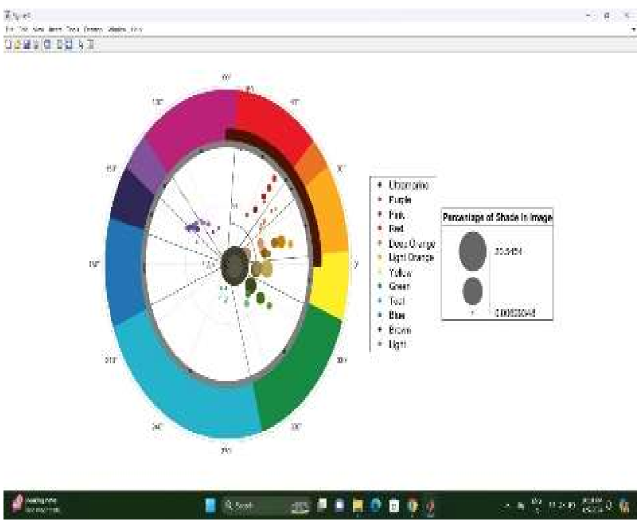


Figure 9: The polar graphical representation of the input image.

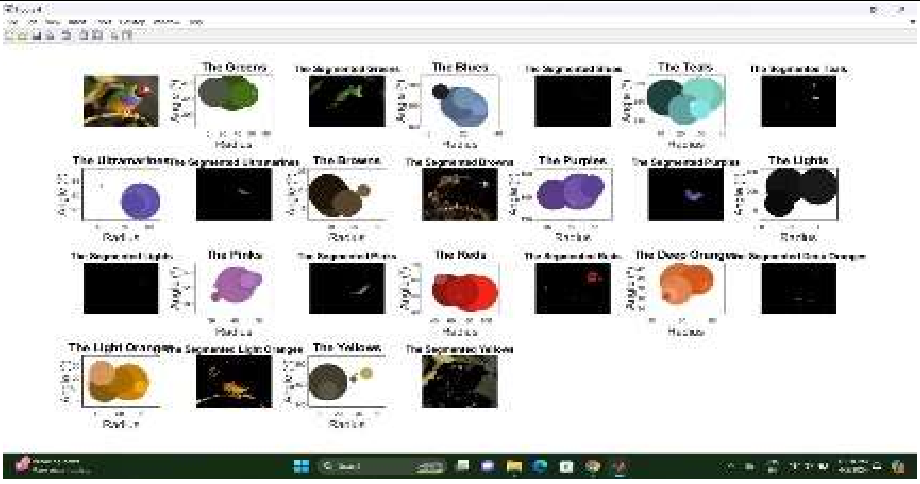


Figure 10: The radius and angular representation of each 12 colours of the image.

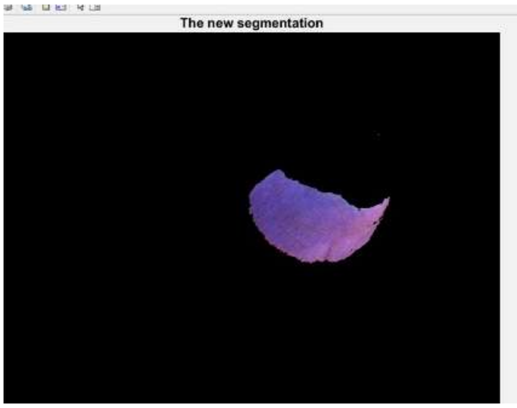


Figure 11: The newly segmented image of the real time bird image.

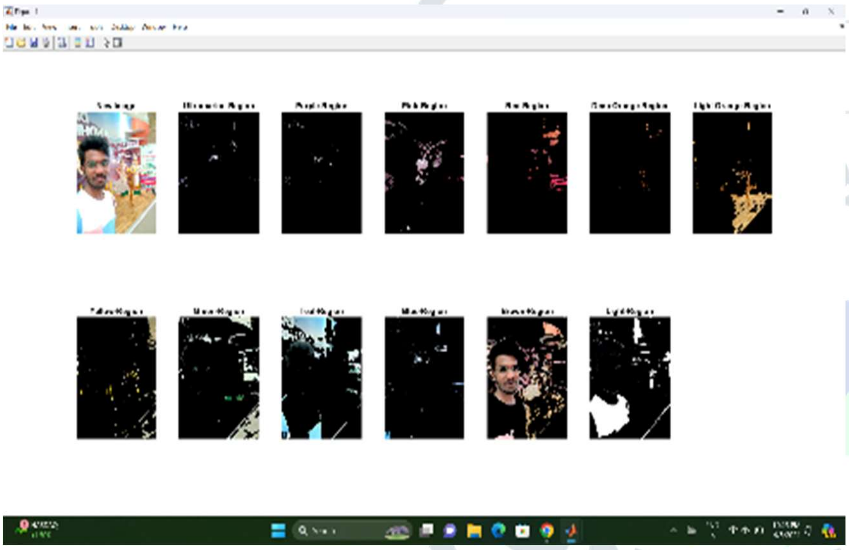


Figure 12: The 12 colour categories of the real time image to understand the qualitative results of the ABSCCA

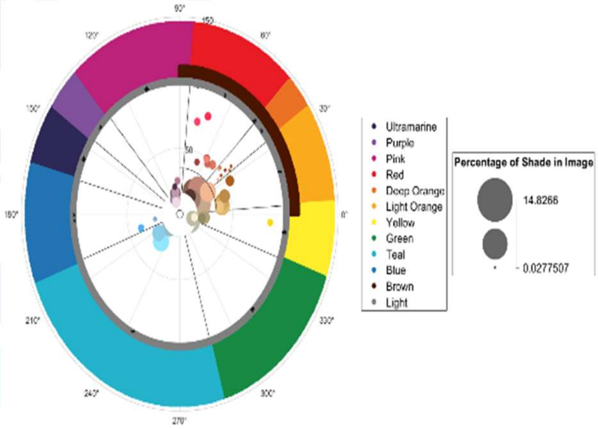


Figure 13: The polar graphical representation of the input image.

CONCLUSION

We have presented a brand-new approach to colour segmentation, labelling, and categorization in this study dubbed ABSCCA. Because of contextual factors and human perception, conventional colour analysis approaches can be skewed. In contrast, our approach only makes use of multi-label systems, fuzzy logic ideas, spatial geometry, and colour theory. Using a cutting-edge polar AB colour space, ABSCCA automatically recognizes the colours contained in an image and categorizing them based on colour theory, and displays their arrangement. In order to effectively bridge the syntactic difference, each detected colour is subsequently given a multi-label name based on irregular membership functions that take into account variations in colour perception. Lastly, the categorized output of ABSCCA can be utilized directly for pure colour segmentation or for controlled, well-informed colour theory-based image segmentation with a straightforward border remodelling phase. Due to its merits, we have been used it in a wide range of practical applications and it has a significant improvement in the colour analysis.

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