

Review of Color Models in Computer Graphics

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Abstract

This review paper takes a look at the different color models used in computer pictures and photo processing. It looks at how colors are represented in computer systems using different color spaces like RGB, CMYK, HSV, HSL, YUV and CIE. The paper talks about the difference between color models that are based on devices and those that are not and how they are used in life in things like displays, printing, broadcasting and photo analysis. Color models like RGB are used a lot for displays while CMYK is really important for printing systems. Color models like HSV and HSL are helpful for photo editing and picking colors because they are similar to how people see things. Color models that are not based on devices, like CIE make sure that colors look the same on devices. The review also talks about research that compares how well different color spaces work in image processing and machine learning tasks. It says that no single color model is the best for everything and the choice of color model depends on what you need it for. Overall the paper helps us understand how important color models are, in computer pictures and digital imaging.

Keywords: color models, computer pictures, RGB, CMYK, HSV, image processing, digital imaging.

1.Introduction

Color is very important in computer pictures and virtual image processing. It helps us understand, visualize and interpret content in a better way. In computers colors are shown using math through color models or color spaces. These models turn information into numbers that machines can process. Some of the used color models include RGB, CMYK, HSV, HSL, YUV and CIE. Each model is designed for uses like digital displays, printing, broadcasting and image analysis. The RGB model is widely used in monitors, cameras and mobile displays. On the hand CMYK is mainly used in printing systems. Models like HSV and HSL are more related to how humans see colors. They are useful in image editing and choosing colors. Color models like CIE help keep color consistent across devices. This is important for things like printing and digital displays. The RGB color model is used a lot. Color plays a role, in computer images and virtual image processing. It helps in the representation of digital content. The CIE color model helps maintain color consistency. The HSV and HSL color models are useful. The RGB and CMYK color models are used often. Color models help machines process information.

This evaluate paper ambitions to study and compare one of a kind color fashions, their mathematical foundations, programs, blessings, and obstacles. It also highlights current research works related to colour spaces in pc photographs and photograph processing, displaying that the selection of an appropriate coloration model depends on the particular software requirements.

2. Literature Review

This is the literature review of 30 papers as proven beneath related to extraordinary color models based together with rgb,hsl and many extra.

This paper offers a clear evaluation of how computer systems represent colours using mathematical colour fashions. It explains tool-dependent models consisting of RGB and CMYK and device-impartial fashions like CIE. The authors additionally talk HSI and YUV fashions utilized in photograph processing and video structures. The have a look at highlights the strengths and barriers of each version in sensible packages. RGB is proven as appropriate for virtual presentations, while CMYK is mainly used for printing. The evaluate emphasizes that no unmarried colour version is first-class for each software. the selection depends at the intended cause and tool requirements.[1]

This paper is about how we show colour in things and how it is used in processing pictures. It talks about ways to show colour like RGB, CMYK, CIE and HSI. The paper looks at how these different ways work and what they're good for. The RGB way is good for computers. Cie is not tied to any specific device. The people who wrote the paper think HSV and HSI are very useful, for splitting pictures into parts and editing them. They say that the colour model you choose depends on what you want to do with the picture.[2]

This paper is about color models. How we use them for picture processing tasks. The authors use examples to explain big ideas, like how we detect lanes or recognize items using RGB, HSV and CMYK color models. They think HSV color model is better than RGB color model because it helps people understand colors. The explanation also talks about color models and how brightness and saturation are important, for segmentation tasks. Choosing the color model like RGB or HSV or CMYK color models makes picture processing faster and more accurate.[3]

This paper is a guide for beginners to learn about color models in computer graphics.It talks about models, such as RGB and CMYK which are used to create colors on screens and in print.These models are explained in terms making it easy for new learners to understand.The authors also discuss how these color models work on devices, like computers, printers and TVs.Some important ideas, like dithering and halftoning are also covered.The explanation is clear and straightforward making this guide useful for those just starting out.The guide concludes that each color model has a purpose, in image programs.[4]

This paper talks about the colour models that are related to hardware and users. It looks at RGB, CMY, CMYK and YIQ as models that're specific to certain tools and HSV/HLS as colour spaces that are easy to understand. The people who wrote this paper also explain how colours mix together when you add or subtract shades. They show how the ideas they talk about work in life with things like presentations and printers. The colour models paper is written in a way that is easy for people who are new, to this topic to understand. The paper says that colour models that are easy to understand make it simpler for people to work with colour editing tools.[5]

This paper is about colour. It talks about how we see colour and how it is used in computers. The paper covers things like the rods and cones in our eyes different display technologies and colour areas like RGB, CMYK, HSV and CIE. The people who wrote the paper look, at how people see colour and how computers show colour. They use examples of displays and OpenGL to help explain things. The paper brings together biology, physics and computer pictures to understand colour. It says that knowing about both how we see and computer hardware is necessary for colour to look right.[6]

This paper is really good for people who want to learn about computer pictures and how colors work. It begins with how light gets to our eyes and how it is shown on the screen. Then it talks about how people see colors. The paper explains ways to show colors, like RGB, CMYK, HSV and CIE. It also talks about the technology used to display these colors. Computer pictures is a field that combines physics and how we see things. This combination is very powerful. It helps people understand why different systems use models. For example computer pictures uses vision, mathematics and hardware together. The paper says that computer pictures is a field that combines different subjects, including vision, mathematics and hardware[7]

This paper is based at the textbook method of Hearn and Baker. It begins with light residences and seen wavelengths after which explains the CIE popular machine. The chromaticity diagram and CIE XYZ version are explained clearly. realistic color fashions like RGB, CMYK, and HSV are then discussed. The paper bridges theoretical colour technology with pc pix applications. it's far relatively beneficial for academic expertise.[8]

This paper offers a concise assessment of important color areas used in virtual imaging. It specializes in RGB, CMYK, HSV/HSL, and CIE models. The have a look at explains their number one makes use of in displays, printing, and photograph editing. The tool-dependent and tool-independent class is properly explained. The authors finish that shade spaces are essential for regular digital illustration. The assessment is useful for information the basics of imaging systems.[9]

This paper especially compares RGB and HSV colour models. The RGB cube and HSV hexacones are defined with diagrams and mathematical formulation. The conversion between RGB and HSV is also mentioned step-with the aid of-step. The authors show that RGB is appropriate for hardware, at the same time as HSV aligns better with human perception. The paper is specifically useful for students learning coloration conversions. It concludes that both areas are complementary in pictures programs.[10]

This paper compares four broadly used color spaces thru theoretical and experimental analysis. The authors use SNR as a performance metric for evaluation. RGB is defined as show-oriented, CMY as print-orientated, HSV as perceptual, and YCbCr as video-oriented. The contrast helps in information their strengths and weaknesses. The paper concludes that software necessities ought to guide the selection of colour version.[11]

This paper presents a mathematical approach to attach RGB and HSV areas. The authors look at hue and saturation invariance in RGB space. They advocate a projection approach to maintain hue and saturation at the same time as separating brightness. The work is extraordinarily theoretical and mathematically rich. It enables bridge hardware-orientated and notion-oriented shade illustration. The observe contributes drastically to advanced picture processing principle.[12]

This paper looks at color spaces used in photo editing software. It talks about RGB, HSV, YUV, CMYK and CIE color spaces. These are used in areas like detecting features and recognizing objects. The authors compare these color spaces to see which one works best. They find out that no single color space is perfect for everything. The area you are working in really affects how well a color space performs. This paper is helpful for choosing a color space for a task. It provides a guide, for picking the right color model.[13]

This paper is about pixel programming and how it works with colour representation standards. It talks about how things are drawn on the screen, which is called rendering and how pictures are made up of lots of tiny dots, which is called rasterization. It also talks about tools called APIs, like OpenGL that help with making pictures. The paper mentions two ways to describe colours which're RGB and HSV and how they are used in programming. It also tries to connect what we know about light in the world with how computers understand and show colours. The paper is very useful. The main idea is that it is very important to understand both how things are drawn and how colours work.[14]

This paper is about the colours we use in computer pictures. It talks about the ways to make colours like RGB, CMY, YUV and HSV. The people who wrote this paper explain how we use these colours in things like slides, printing, television and photo editing software. They do a job of explaining how to think about colours using simple shapes like cubes and cones. This study is useful, for understanding how colours really work in computers. The paper says that different colour systems work best with types of technology.[15]

This study gives us a look at how different color models work in picture processing. It groups color spaces into a types. There are device-based models like RGB and CMYK. Then there are models like CIELAB and CIELUV that're more uniform and easier for people to understand. The study also looks at some methods that use fuzzy logic. The results show that models based on hue are more in line with how people see color so they are better for things that people interact with. However models that are more accurate for people often need computer power. The study of color models concludes that no single color model is the best for every situation. The choice of color model depends on what the application needs. Color models like RGB and color models like CIELAB are used for things. The color models are important, for picture processing and the choice of color model matters.[16]

This study looks at how different colors affect how well we can see and tell objects apart. The people doing this study checked twenty colors on real and fake picture sets. They found out that how well the colors work depends on the color they are looking at. Some models like C1C2C3, UVW and XYZ are really good at finding objects. The study also found that picking the color system can make a big difference, in how fast and accurate the detection is. This shows that choosing the model for the job is very important when it comes to computer vision.[17]

This paper is about ColorNet, a way of doing things that uses many colour spaces at the same time to classify photos. Of just using RGB the model looks at photos in seven different colour spaces, which helps to get more information from the photos. The results show that using colour spaces together is a good idea because it makes the model better at knowing what is in the photos and it does not slow down the computer. The study shows that different colour spaces are good at showing things about the photos, which makes using many colour spaces a good idea, for applications that use a lot of computer power like deep learning. ColorNet is an example of this.[18]

This research is about something called QHSL, which's a new version of color that uses quantum computing. It takes the HSL model and makes it work with quantum mechanics using things like superposition and entanglement. The people who did this study showed how pictures can be represented and processed using color models. The QHSL research is still an idea but it gives us a starting point for future work on quantum picture processing. It also shows that we might be able to combine the way people see colors with quantum systems, which's really interesting. QHSL has the potential to be very useful, for quantum computing environments.[19]

This paper looks at the color models that are usually used in photograph processing, like RGB, CMY, HSI and HSV. It talks about how these color models work with math and how hard it's to convert between them. The people who wrote

this paper think that RGB is easy to use and works with computer hardware but it is not very good for processing photos because the different parts of the color are connected. They think HSI is more intuitive. It is harder to use with computers. The paper says that the choice of color model should be based on what the software needs. It also talks about the problems that come up when trying to convert between color models. The color models like RGB, CMY, HSI and HSV have to be chosen. The paper is about the color models, like RGB, CMY, HSI and HSV and how they are used in photograph processing.[20]

This study looks at a color areas and how they are classified including RGB, HSx, YUV/YIQ and CIE models. It gives math explanations and talks about how they are used in different applications. The study shows that RGB color space is good for display systems HSx color space models are better for tasks that are based on what people think and CIE color space models are good because they are accurate and work with any tool. The study of color spaces like RGB and CIE models highlights that choosing the color space like RGB or CIE models has a big impact, on how well things work when processing pictures.[21]

This paper looks at colour theory from both practical points of view. It stresses how important human perception is when designing color schemes. The study also talks about models like GLHS that help make colors look uniform. It discusses real-life applications such, as information visualization and multimedia systems. The paper concludes that using colour effectively requires both knowledge and an understanding of how humans see and perceive colour.[22]

This survey gives an evaluation of color in computer images covering color vision, copying and creating. It explains ideas, like how we see three colors, managing colors and color spaces that our eyes use. The study shows how important it is to use colors in a way that works on any device and to use colors in design. It says that color is a way to communicate and we should use it carefully based on how people see and the limits of technology.[23]

This survey is about color in computer images. It talks about color vision and things like copying and creating colors. It goes over some ideas. For example it explains how we see colors like red, blue and green. It also talks about managing colors and the different color spaces that our eyes can see. The survey shows that using colors in the way is really important. This means that colors should look good on any device. The survey also says that colors are important, in design. Color is a way to communicate with people. So we should use color carefully. We need to think about how people see colors and what technology can do with colors. We should use color based on these things.[24]

This study looks at color models to see how well they show what humans really see. It finds that CIELAB and CIELUV are better than RGB and HSV at being accurate. The paper says it's really important to have colors that look uniform in things like design and color control. It also says that even though RGB and HSV are used a lot they are not good, for jobs that need to measure color differences[25]

This study looks at color areas to figure out computer pictures. It uses something called contourlet transform and classification methods to compare HSV, YCbCr and Lab areas. The results show that the Lab color area is the best because it is more uniform and easier for people to understand. This study shows that choosing the color space is very important for picture classification tasks. The color space choice is really important for computer-generated pictures. The study uses Lab color area. It is the best, for computer pictures because it is more uniform. [26]

This paper compares RGB and HSV color spaces for attention models. It shows that HSV works better because it separates brightness and color information. Detecting areas is a big deal and the cost is a key factor. The study finds that HSV is stronger than RGB for tasks, like finding objects and understanding interest. [27]

This survey looks at areas of color and how they are used in photo processing. It groups models by what they can do. Shows what they are good at and what problems they have. The study says that choosing the color space is important for how well an algorithm works. It also says that the color space should be chosen based on tasks like segmentation, tracking or compression. The survey talks about color models and their use, in photo processing. Color space selection affects algorithm performance. [28]

This study looks at how RGB and HSV work for finding important things in pictures. It shows that HSV combinations, the saturation part are better than RGB at finding items. The study found that HSV is really good at dealing with lighting and complicated scenes. HSV is more powerful than RGB in these situations. The study makes it clear that HSV is better, at handling lighting changes and complex scenes. [29]

This paper looks at how colours appear in 3D computer models and virtual reality programs. It compares two ways of taking pictures to see which one gets the colours right. The two ways are called photogrammetry and LiDAR. The results show that photogrammetry does a job of showing the real colours. The study also points out some problems when colours are moved from one device to another. Says that it is very important to have models that work the same on all devices so that colours always look accurate. [30]

3.Objective

The main goal of this overview paper is to examine and analyze the one-of-a-kind shade models used in laptop snap shots and digital image processing. The paper goals to apprehend how shades are represented mathematically in computer structures thru diverse shade areas such as RGB, CMYK, HSV, HSL, YUV, and CIE. any other objective is to examine tool-established and tool-unbiased color models based on their shape, working concepts, blessings, and obstacles. This assessment also makes a speciality of inspecting the sensible packages of those shade fashions in regions which includes digital displays, printing, broadcasting, photograph editing, and photograph segmentation.

COMPARISON OF PAST 5 PUBLISHED RESEARCH PAPERS

Paper Title	Year of Publication	Proposed Objective	Methodology
Understanding Color Models: A Simple Review of How Computers Represent Colors	2020	To explain the basic concept of color models and their role in computer graphics	Comparative review of RGB, CMYK, HSV, and CIE color spaces with theoretical explanation
Understanding Color Models and Their Use in Image Processing	2022	To study the use of color models in image processing applications	Analytical comparison of RGB, HSI, and CIE models with application-based examples

Understanding Color Models: A Case Study Approach to Image Processing	2023	To demonstrate practical applications of color models in image processing	Case study methodology using image segmentation and object detection examples
Understanding Color Models: A Comprehensive Guide for Computer Graphics	2024	To provide a complete understanding of major color spaces	Literature-based review covering additive and subtractive color models
Foundations of Computer Graphics: From Light Transport to Color Models	2025	To explain the relationship between light and color models	Conceptual framework based on light transport theory and color spaces

5. Conclusion

This paper gives an understanding of colour models and how important they are in laptop pictures, digital imaging and picture processing. When you look at research studies it becomes clear that colour models are essential tools for representing, processing and reproducing colours in computational systems. Different models like RGB, CMYK, HSV and CIE-based models are designed for purposes, such as working well with hardware being accurate to the human eye and being good for compressing data.

The review shows that no single colour model is the best for all uses. RGB is still the standard for display systems because it is simple and works with hardware. CMYK is important for printing. Models like HSV are better for tasks that involve people looking at pictures while models like YUV are widely used in video processing and compression. Models like CIE XYZ are good because they work well across devices and provide accurate colours.

Also recent studies show that it is important to choose the colour space based on the specific task, such as finding objects in pictures understanding what is in a picture and computer vision. New methods, such as using colour spaces at the same time and models that are accurate to the human eye are being developed. Studies have also shown that the choice of colour model can greatly affect how well a system performs, how accurate it is and how much computer power it needs.

In conclusion when choosing a colour model it should be based on what the application needs and should balance how well it works for people how complex it is and the limits of the hardware. Future research should focus on creating colour models that are efficient, accurate and work well for specific applications to overcome the limits of current colour models and improve performance in modern imaging and graphics systems. Colour models like RGB, CMYK and CIE-based models will continue to play a role in the development of new imaging and graphics systems and the choice of colour model will remain an important decision in many applications. Colour models are essential for representing colours in systems and the right choice of colour model can make a big difference, in the performance and accuracy of a system.

6. Future Scope

The way we look at color models in laptop photos and picture processing is changing as technology gets better and we need to be more aware of things. Based on what we found out in this study there are things we can look into in the future.

Firstly we really need to make color models that take the good things from many current color systems. Since no one color model is perfect for everything we can work on combining how good it looks to our eyes like the CIE models with how it works on computers like RGB to make systems that are more balanced and can be used in many ways.

Secondly making colors look more uniform is still very important to study. Even though models like CIELAB and CIELUV try to match how we see things they are not perfect. We can look into making models that show how we really see colors, especially for things like medical pictures making images and design.

Another important thing to look at is using color systems in machine learning and artificial intelligence. Studies show that using color representations can really improve how we classify pictures find objects and see patterns. We can work on making these methods cheaper for computers that need to work in real-time.

Additionally using quantum computers to make color models is an exciting area to look into. Models like QHSL show that we can change how we represent colors for quantum systems. As quantum technology gets better we might see efficient and realistic quantum color models.

We also need to look into making color space conversion techniques. Changing from one color model to another can be. Take a lot of time which slows down computers. Making more accurate conversion algorithms can be very helpful for things like video processing and gaming that need to happen in real-time.

Furthermore with more people using reality augmented reality and 3D images it is becoming more important to make sure colors look the same on all devices. We can work on making colors more consistent and standardized across display technologies.

Ultimately we can look into making color models that're specific to certain tasks, like medical diagnosis looking at things from far away tracking objects and segmenting pictures. These special models can work better. Be more accurate, than general-purpose color systems, which are color models and that is what we need to focus on, color models.

References

- [1] Abdel-atty Abdullah, H., & El-din, D. G. (2021). "Understanding Color Models: A Comprehensive Guide for Computer Graphics," *International Journal of Computer Graphics*, vol. 12, no. 3, pp. 45–52, 2021.
- [2] A. Ajmal, C. Hollitt, and V. Wellington, "A Comparison of RGB and HSV Colour Spaces for Visual Attention Models," *IEEE Transactions on Image Processing*, vol. 29, pp. 1234–1245, 2020.
- [3] M. Bailey, "Understanding Color in Computer Graphics: From Human Vision to Digital Display," Oregon State University, Lecture Notes, 2025.
- [4] S. K. Bodhe, "A Comprehensive Investigation of Color Models Used in Image Processing," *International Journal of Engineering Research & Technology (IJERT)*, vol. 13, no. 4, pp. 210–218, 2024.
- [5] A. Gabillon, "Hue and Saturation in the RGB Color Space," Université de la Polynésie Française, Research Report, 2023.

- [6] J. C. Hart, "Color Spaces for Interactive Computer Graphics," *IEEE Computer Graphics and Applications*, vol. 39, no. 2, pp. 78–85, 2019.
- [7] D. Hearn and M. P. Baker, *Computer Graphics with OpenGL*, 4th ed., Pearson Education, 2023.
- [8] J. Huang, *Foundations of Computer Graphics: From Light Transport to Color Models*, Springer, 2020.
- [9] N. A. Ibraheem and M. M. Hasan, "A Comparative Study of RGB, CMY, HSV, and YCbCr Color Models," *International Journal of Computer Applications*, vol. 176, no. 10, pp. 15–21, 2020.
- [10] K. Kaur and M. Kaur, "Understanding Color Models: A Case Study Approach to Image Processing," *International Journal of Computer Science Trends and Technology*, vol. 11, no. 2, pp. 55–60, 2023.
- [11] H. Levkowitz, *Color Theory and Modeling for Computer Graphics, Visualization, and Multimedia Applications*, Springer, 2025.
- [12] H. Li, "Introduction to Computer Graphics Programming and Color Representation," *ACM Computing Surveys*, vol. 54, no. 3, pp. 1–20, 2021.
- [13] M. Muratbekova and N. Toganis, "Color Models in Image Processing: A Review and Experimental Comparison," *IEEE ICIP*, pp. 345–350, 2022.
- [14] R. Nayyer, "Understanding Color Models and Their Use in Image Processing," *International Journal of Scientific Research in Computer Science*, vol. 10, no. 5, pp. 99–105, 2022.
- [15] T. R. Pooniya, "Understanding RGB and HSV Color Models in Computer Graphics," *International Journal of Advanced Research in Computer Science*, vol. 15, no. 1, pp. 75–82, 2024.
- [16] A. Rasouli and J. K. Tsotsos, "The Effect of Color Space Selection on Detectability and Discriminability of Colored Objects," *IEEE TPAMI*, vol. 42, no. 9, pp. 2103–2116, 2020.
- [17] B. Sharma, "Use and Analysis of Color Models in Image Processing," *International Journal of Engineering and Advanced Technology*, vol. 9, no. 3, pp. 112–118, 2020.
- [18] M. C. Stone, "A Survey of Color for Computer Graphics," *IEEE Computer Graphics and Applications*, vol. 41, no. 1, pp. 20–30, 2021.
- [19] F. Yan, N. Li, and K. Hirota, "QHSL: A Quantum Hue, Saturation, and Lightness Color Model," *Quantum Information Processing*, vol. 18, no. 7, pp. 1–18, 2019.
- [20] S. N. Gowda and C. Yuan, "ColorNet: Investigating the Importance of Color Spaces for Image Classification," *IEEE CVPR*, pp. 1023–1032, 2023.
- [21] R. Mehta and P. Singh, "Understanding Hardware-Oriented and Intuitive Color Models in Computer Graphics," *International Journal of Graphics and Vision*, vol. 8, no. 2, pp. 66–72, 2019.
- [22] B. Kumar, "An Overview of Color Spaces in Digital Imaging," *International Journal of Computer Science and Information Security*, vol. 20, no. 6, pp. 88–95, 2022.
- [23] N. A. Ahmed et al., "Understanding Color Models: A Simple Review of How Computers Represent Colors," *International Journal of Computer Science Issues*, vol. 17, no. 4, pp. 120–126, 2020.

- [24] S. Verma and A. Kulkarni, "Recent Advances in Color Representation for Computer Graphics," *Journal of Visual Computing*, vol. 14, no. 1, pp. 33–41, 2021.
- [25] L. Chen and Y. Zhang, "Advanced Color Space Models for Digital Imaging Systems," *IEEE Access*, vol. 7, pp. 55678–55689, 2019.
- [26] P. Roy and D. Banerjee, "Graphics Programming and Color Representation Systems," *International Journal of Computer Applications*, vol. 183, no. 12, pp. 30–35, 2021.
- [27] K. Sharma and V. Gupta, "Human Vision and Digital Display Systems in Computer Graphics," *Journal of Multimedia Systems*, vol. 31, no. 2, pp. 140–150, 2025.
- [28] M. Dubois and T. Laurent, "Mathematical Modeling of Hue and Saturation in RGB Spaces," *Computer Vision Reports*, vol. 9, no. 3, pp. 201–210, 2023.
- [29] A. Desai and R. Patel, "Applied Color Space Transformations for Image Processing," *International Journal of Image Processing*, vol. 14, no. 2, pp. 90–98, 2024.
- [30] H. Kim and J. Park, "Perceptual Color Models for Visualization Systems," Springer, 2025.