VOLUME - 9, ISSUE - 8, August - 2020 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

Dental Science

ENGINEERING COLOUR DETECTION IN DENTISTRY .

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ABSTRACT During the past half decade, the dental profession has experienced the growth of a new generation of technologies devoted to the analysis, communication and verification of shade. An accurate determination of the natural tooth color range is essential for the process of color matching of a restoration or prosthesis to the other dentition. Despite the variety of methods available today for assessing tooth color, such as the use of a shade guide, spectrophotometers , colorimeters or the computer analysis of digital Images , measurement of tooth color remains a challenge

KEYWORDS : Color , Color measurement and analysis , Image classification technique

INTRODUCTION

Light scattering and absorption within enamel and dentine give rise to the intrinsic tooth color, and the properties of dentine can play a major role in determining the overall tooth color since enamel is relatively translucent. Factors influencing the tooth color may include genetic, congenital, metabolic, chemical, infectious and environmental. The shade and appearance of tooth is a complex phenomenon, many factors such as lighting conditions, translucency, opacity , light scattering, gloss, and the human eye and brain influence the overall perception of the tooth color . [1]

Color is the visual perceptual sensation of light that defines the appearance of our surroundings . To determine the color of an object , one needs to consider the nature of the light source that illuminates an object , the spectral reflectance properties of the object viewed, and the nature of human color perception (Berns 2000). Variation in any of these three aspects may affect the visual perception of color . [2]

In the 1990s , Albert Henry Munsell , an art professor in Boston , developed one of the color-modeling systems and a notation for precisely naming colors . Munsell's system identifed three independent components of color – Hue , Value , Chroma . Johathan Itten is the first to realize the harmony in color pairs according to their spatial relationships. He defined and identifed strategies for successful color combinations . [3]

In human color vision the first step is the sensory process that are the stimulation of light receptors in the eyes , conversion of the light stimuli or images into signals and transmission of electrical signals containing the vision information from each eye to the brain through the optic nerves . This information is processed in several stages , ultimately reaching to the visual cortices of the cerebrum .Color sensors play a significant role in equipment such as color-monitor calibration , color printers and plotters , paints, textiles, cosmetics manufactures and medical applications such as blood diagnostics , urine analysis and dental matching . A common requirement in the field of color sensing is that of color identification or sorting of objects by colors. Detecting color of an object is useful electronic application. It is done using a color sensor module . Chip is designed to detect the color of light incident on it . It has an array of photodiode. These photodiodes are covered with filters . Sensors having red filter over them can measure only the component of red in the incident light , other sensors have green and blue filters . Any visible color is broken into three primary colors .

Light-to-frequency converters

Light - to- Frequency Sensors convert light intensity to a digital form for direct interface to a microcontroller . The output of the device is square wave or pulse train whose frequency is linearly proportional to the light intensity , thereby enabling the device to interface directly to a microprocessor . These converters are designed for applications such as ambient light measurement , light absorption / reflection in products such as white goods , photographic equipment , colorimetry , chemical analyzers and display contrast controls or any system requiring a wide dynamic range, and / or high resolution digital measurement of light intensity . [4]

Accurate color matching system is mainly result based on images analyzing and processing techniques of recognition system .System consist of three parts, which are data collection from digital teeth color images, data preparation for taking color analysis technique and extracting the features , and data classification feature. Due to many formed features from each color space, it requires addition method for reducing the number of features by choosing the essential information like Principal Component Analysis method . Combining its feature selection technique to the classification process, using K Nearest Neighbour (KNN) classifier algorithm improves the accuracy performance of this system . [5]

Shade determination for direct and indirect restorations has always been a challenge for the esthetic dentist . Clark in 1931 described this in the Color Problems in Dentistry . The late 1990s marked the birth of a new industry in dentistry with commercially available instrument-based color measurement systems .Shade - matching technologies have been developed in an effort to increase the success of color matching , communication , reproduction and verification in clinical dentistry , and , ultimately , to increase the efficiency of esthetic restorative work .

Spectrophotometers , colorimeters and imaging systems are useful and relevant tools for tooth color measurement and analysis , and for quality control of color reproduction .

Spectrophotometric measurement methods employ computer calculations, based on color science and theory , and allow quantitative evaluation . It allows all anterior teeth , upper and lower, from one canine to the other, to be recorded on one occasion, using CIE L*a*b* parameters as described in the Munsell system . [6]

A spectrophotometer contains a source of optical radiation , a means of dispersing light , an optical system for measuring , a detector and a means of converting light obtained to a signal that can be analysed. The data obtained from spectrophotometers is manipulated and translated into a form useful for dental professionals . It measures one wavelength at a time from the reflectance or transmittance of an object .

This method is objective and is more accurate ; however , the quantitative spectrophotometric evaluation is limited to reading one point at a time , there is a lack of standardization , high costs , and relatively low performance , with respect to agreements of the computer - aided devices . Incorrect color

reading from the loss of a fraction of light entering the tooth , the so called "edge-loss error", is a frequent shortcoming of contact –type devices .[7]

Colourimeters have colour filters that approximate the spectral function of the standard observer's eye and are generally designed to measure colour in X ; Y ; Z tristimulus terms or in CIE Lab values. The disadvantages of using colourimeters for measuring tooth colour include : the instruments are designed to measure flat surfaces , teeth are often not flat and can have surface anomalies .[8]

Colorimeters measure tristimulus values and filter light in red , green and blue areas of the visible spectrum. Colorimeters are not registering spectral reflectance and can be less accurate than spectrophotometers (aging of the filters can additionally affect accuracy) .[9]

Color systems used commonly in dental clinical and research settings are the Munsell color order system , the CIE L*a*b* (CIELAB) and CIE L*c*h* color Coordinate systems . The RGB color system is used to describe tooth color in digital Images and all visual media devices that record, measure, manipulate or display digital Images, such as digital cameras, colorimeters , computers and display monitors .

The Munsell color order system defines the color of an object using three independent dimensions : Hue, Value and Chroma (Kuehni 2002). Hue is an attribute of a perceived color associated with the predominant wavelengths of light causing the particular color stimulus. Value is an attribute of a perceived color associated with its lightness, ranging from black to white. Chroma is amount of color saturation of a perceived color at a given lightness (Berns 2000) .

The Munsell color system was developed based on visual color matching and not spectral properties , an advantage in clinical use because the clinical endpoint is a visually matching shade of a restorative material also , any color mismatch can be described in terms of Hue , Value and Chroma , disadvantage is that one cannot use the Munsell color system to quantify color differences based on spectral properties and hence limits the system's use and scope in research .

CIELAB color space

The Commission Internationale de l'Eclairage (CIE) developed the CIE 1976 L* ,

a*, b* color space, with the official abbreviation CIELAB . The L* coordinate or axis quantifies the lightness and has a scale from zero to 100 . The a* axis represents redness greenness with zero being achromatic , a negative a* value representing more greenness than redness ,and a positive a* value representing more redness than greenness .The b* axis represents yellowness - blueness with zero being achromatic , a negative b* denoting more blueness than yellowness , and a positive b* denoting more yellowness than blueness .[2]

New color difference formulae are being developed to make a single-number shade pass / fail equation for evaluating the small to medium color differences. The CIEDE2000 color difference formula (DE00) based on the CIELAB , which includes not only lightness, chroma, and hue weighting functions , but also an interactive term between chroma and hue differences for improving the performance for blue colors and a scaling factor for the CIELAB a* scale for improving the performance for gray colors .[1]

RGB color system

The RGB color model is an additive color model in which the primary colors : red , Green and blue are added in different proportions to reproduce a broad range of colors (Hunt 2004) . This color model is used primarily in visual media devices such as digital cameras, computer monitors and video projectors, and is a device-dependent color space. Communication with the dental laboratory can be improved by using the digital photographic image of the target tooth , along with the visually selected shade guide teeth. Due to advances in photography and computer technology , the use of a digital camera is now widespread for color imaging . The instrument is capable of recording digital data from an object and producing an image on a computer screen. Images produced via a digital camera may be analyzed using appropriate imaging software, enabling the collection of color values from the whole or parts of such images .[7]

Images classification is a technique and method to identify images according to their content or feature. In order to provide the suitable teeth color images , addition algorithm is required to classify the features based on formed features from each color space properties. Principal Component analysis (PCA) is one of the popular methods . Selection of teeth images for dental color matching system is done using PCA and K-Nearest Neighbors algorithm (KNN) classifier algorithm . The most well known of dimensionality reduction algorithm is PCA . The first step of this system is collecting the images data from shade guide database . The images of this system , is obtained from digital camera . The second step is data preparation to determine the color space model of this system . There are three color space model which are used for this system . Those are RGB , HSV , and LAB . HSV is abbreviation from Hue , Saturation and Value . RGB using basic element of Red , Green and Blue . LAB is the color models based on the wavelength of the light . Each color system model is applied at all images data . From the color model result one can analyze the characteristic of each color model using color moment technique . The output from this step is the variance feature of teeth color in database . The variance feature result is classified based on ID number of teeth from the shade guide database system using KNN classifier . K-Nearest Neighbors algorithm (KNN) is a non-parametric method used for classification and regression . Principal Component Analysis is a dimensionality reduction which is used for compresion and recognition problem . The output features from PCA algorithm is used to establish the predefined tooth type class that best describes the new tooth type .[10]

CONCLUSION

Patients are demanding contemporary esthetic dentistry , which has prompted the industry to continuously raise the bar with regard to esthetic detail . Many factors can influence the perception of color ; by taking advantage of today's shade-matching technology , the subjectivity of color assessment can be minimized and accurate diagnosis of a restoration's shade is more easily communicated .

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