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DSC 412
11 December 2024
Professor Embry

Milestone Project Essay

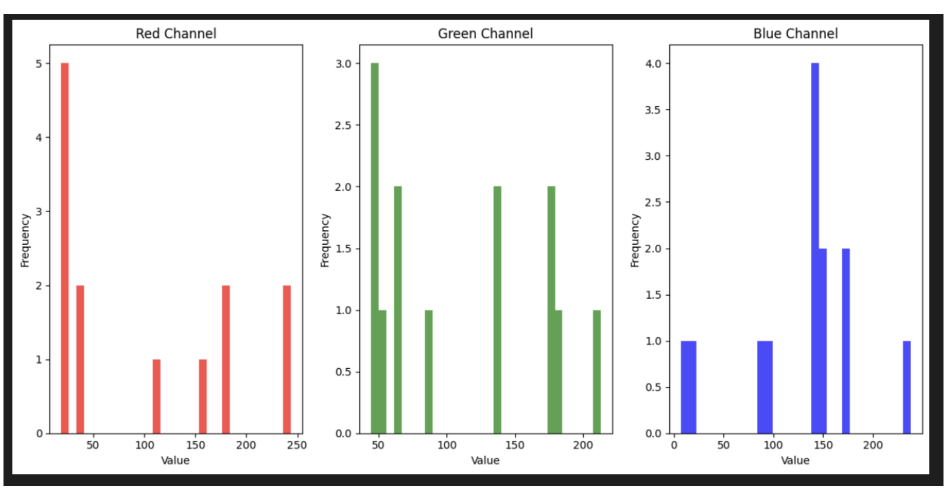
Abstract

As society continues to advance in society, much of the medical field is leaning towards more technical implements into their practice, whether that be inside the facilities or their patients. Color blindness affects millions of individuals worldwide, with much of the ongoing research focusing on genetic and molecular therapies, however, working at the molecular level presents its challenges. This study explores the potential of machine learning to address color blindness by integrating insights from gene therapy and neural anatomy to develop predictive models for medical devices, such as smart glasses or biosensors. A random forest regression model was used to analyze RGB pixel intensities and train algorithms. Using a train-test split the model was able to evaluate the RGB distributions, revealing that the green channel is the most accurate color predicted with an error rate of 59.37%. Much of the future work will consist of continuous training and developing Moore sophisticated models for complex imaging and mass demand.

Background

Much of the ongoing research being done on color blindness focuses on the three genes that have been associated with color blindness, of course a primary focus on solving this problem is working on gene therapy. While much advancements have been made by working with genes, working at the molecular level is challenging. As technology advances and more so technology becoming more prominent in medical devices, machine learning could introduce potential solutions to solving problems such as color blindness by creating train and test sets for the users to rely on. Previous research has focused on modifying the image in itself, being able to translate the image into a color blind friendly image (Yang, 2017). Though, what if we could use these machine learning algorithms and take what is known with gene therapy and overall the anatomy of the brain and eye, and create something that has been seen before; a biosensor. Through trained-test algorithms these could be implemented in a medical device or even something like smart glasses to create that color blind friendly image.

Data Analysis



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(Figure 1. RGB Channel Density)

To begin, a set amount of images ranging from Red, Green, and Blue are pulled, some that contain all three, two, or one color are essential in providing a well rounded trained model. When the model was run, it was observed that the red channel peaks at lower pixel intensities indicating the sample data is dominated by darker shades of red, the green channel also had a right-skewed peak but it is much smaller and the histogram is more flat indicating a pretty evenly distributed shades of green present amongst all images. The blue channel is symmetric indicating that our sample data contains a blue evenly balanced amongst all images.

Data Augmentation

To be able to analyze the accuracy of the detection of color, the images were converted from their original file format (e.g.,) to arrays of RGB values through the “OpenCV” package. Once the data was extracted they were stored into CSV files.

Model Selection

Random forest tree regression model was used for this research due to its ability to group complex and large datasets. Since some sample images contain a variety of colors, random forest is able to group the gaps between the colors seen in the sample images. This model also allows to showcase non-linear relationships, especially since input features such as pixel intensities, surrounding context, or other data is seen when working with these sample images, by resembling decision trees it can model these groups effectively. By averaging the predictions of multiple decision trees, random forest reduces the risk of overfitting especially when the model is trained on high dimensional data which is common in image-related tasks/research.

Training Methodology

A train-test split model was used to ensure accuracy on how the model will perform with new and unseen data. The data is arranged in a way acceptable for the split test, it is then split into two sets a “train” and “test” set, a majority of the data goes into training to ensure better results for the test set. For this research, 80% of the data was used for training with the remaining 20% in testing. Train-test split ensures avoidance of over or underfitting through various validation features within the training set.

Results

The code includes a machine learning pipeline for predicting the average RGB values of images based on extracted features. It begins by loading and processing image datasets, resizing them for consistency, and extracting features like the mean and standard deviation for each RGB channel. Data analysis is performed through histograms and scatter plots to visualize the distributions and relationships in the data. The model evaluated the metrics such as Mean Squared Error (MSE) and R^2 scores, which predictions visualized through scatter plots and actual vs predicted color comparisons, the green channel had the highest accuracy out of the three with an error rate of 59.37.

Future Research

With all data considered, it can be said that these models offer precise results of determining RGB colors on a trained algorithm. Continuous training sets and exploring related models to perform at a higher level will be useful in applying this in the proposed biomedical devices. The next phase would consist of perfecting these algorithms and eventually introducing the usage of biomedical devices. Future work will consist of introducing the model to a variety within the RGB scale but also introduce new colors to the model. Along with this, developing more sophisticated models that can accurately predict and apply colors to grayscale images, models could focus on improving the realism and consistency of colorized images in complex images (Huang, 2022).

Stakeholder Acknowledgments

The primary stakeholders for this research include the colorblind individuals and Brain-Computer Interface (BCI) companies. The model has the potential to significantly benefit these groups by being integrated into neural implants or assistive devices that can correct perceived images for colorblind users, enabling them to experience a more accurate color spectrum. However, the potential downside, as the model could interfere with the perception of colors that patients already see correctly, potentially leading to discomfort, for this stage, the stakeholders have not yet been able to try the model, so direct feedback regarding its effectiveness or usability is not available. Future work could center around collaboration with these groups to refine the model. With all this considered, I would like to thank Professor Embry for assigning this project, for his valuable guidance and support throughout this project. It has been a very unique experience uniting the interdisciplinary field of STEM with machine learning strategies.

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Citations

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