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Implementation of a dynamic software method for verifying color blindness images

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Abstract: This paper presents a novel approach for creating dynamic test images to assess color blindness. It explores both statistical and dynamic image generation methods designed to form test signals, with a focus on the essential principles of color processing and representation. Through innovative algorithms, the study enables a reliable differentiation in color perception, aimed at enhancing diagnostic accuracy in color blindness assessments. The method offers a scalable framework for testing, with adaptable parameters that allow it to cater to various diagnostic requirements. Furthermore, the dynamic nature of the proposed images enables more effective testing by simulating real-world color variations, which can impact the clarity and reliability of test results. The findings contribute to improved methodologies in color diagnostics and have the potential for broader applications in areas such as medical imaging, television systems, and visual quality assessment, which are highly reliant on accurate color representation.

Keywords: Color blindness assessment, dynamic image generation, test signals, color processing, diagnostic algorithms, color representation, visual quality assessment, adaptive color testing;

Wdrożenie dynamicznej metody programowej do sprawdzania obrazów pod kątem daltonizmu

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Streszczenie: W artykule przedstawiono nowatorskie podejście do tworzenia dynamicznych obrazów testowych do oceny daltonizmu. Omawia zarówno statystyczne, jak i dynamiczne metody generowania obrazów, które mają na celu formowanie sygnałów testowych, koncentrując się na kluczowych zasadach przetwarzania i reprezentacji kolorów. Dzięki innowacyjnym algorytmom badanie umożliwia wiarygodne rozróżnianie percepcji kolorów, co ma na celu zwiększenie dokładności diagnostycznej w ocenie daltonizmu. Metoda oferuje skalowalne ramy testowe z możliwością dostosowania parametrów, co pozwala na jej zastosowanie w różnych wymaganiach diagnostycznych. Dynamiczny charakter proponowanych obrazów pozwala na bardziej efektywne testowanie poprzez symulację rzeczywistych wariacji kolorów, co wpływa na klarowność i wiarygodność wyników testów. Wyniki badania przyczyniają się do doskonalenia metodologii diagnostyki kolorów i mają potencjał do szerszych zastosowań w takich obszarach, jak obrazowanie medyczne, systemy telewizyjne i ocena jakości wizualnej, gdzie dokładna reprezentacja kolorów odgrywa kluczową rolę.

Słowa kluczowe: Ocena daltonizmu, dynamiczne generowanie obrazów, sygnały testowe, przetwarzanie kolorów, algorytmy diagnostyczne, reprezentacja kolorów, ocena jakości wizualnej, adaptacyjne testowanie kolorów;

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1. Introduction

The quality of color reproduction is one of the main indicators of the performance of television and other devices, depending on the compression methods, resolution and other factors used. It depends both on the characteristics of the components of the video system and on the conditions of image observation on the transmitting and receiving sides [2, 3].

A characteristic in which it is possible to more adequately determine the Euclidean distance between color points in an equal-contrast color space, taking into account all available data [6]. The use of the new space for solving practical problems, in particular, the evaluation of the quality of color transmission for various applications, is investigated and proposed in works [5, 6], in which metrics are developed and investigated.

In the field of television, research in this direction began in 1996 [5–6], taking into account the idea of the adaptive nature of color perception. These studies were also reflected in the contributions of Ukraine [5]. On the basis of these studies, the Research Commission of the 6th radio communication sector of the International Telecommunication Union (ITU-R) conducts research aimed at the problem of developing adaptive systems of the future and systems for evaluating the quality of reproduction in television.

One of the results of these studies is the adoption of Recommendations ITU-R BT.1691 and ITU-R BT.1692. Until 2002, studies were based on the CIECAM97s colorosur model, and on the basis of this model, the first estimates of the characteristics of the perception of color television images were obtained. With the adoption of the CIECAM02 model in 2002, research continued, and appropriate estimates were obtained based on this model [4].

To obtain estimates, a model was used that corresponds to the formulas given in and describes the direct and inverse transformation of coordinates between the MKO space of 1931 and equal-contrast color coordinates in the CIECAM02 space.

These studies made a significant contribution to the development of the scientific base for the creation of television systems and other video applications of a new level. They contribute to a better understanding of the properties of visual perception and the adaptive characteristics of human vision that depend on the conditions of observation. This approach improves the quality of color reproduction and provides more accurate color rendering in various applications, such as television, video recording, medical diagnostics, etc.

As a result of these studies, significant progress has been made in improving the quality of color reproduction in television systems and other video applications. This contributes to a more accurate reproduction of real colors and provides a more convenient and pleasant viewing of television programs and video materials.

Conclusion, depending on the compression methods used, resolution and other factors, there can be a significant deviation in the quality of color reproduction in television systems and other video applications. Until now, classical colorimetry was used for the construction of television systems, which assumes the equality of color coordinates of image details on the transmitting and receiving sides of the MKO-31 system.

New color vision models allow creating more realistic color reproduction, as well as developing new spaces for color measurement and metrics for evaluating the quality of color reproduction. The use of these models and metrics allows for a more accurate comparison of different systems and sets standards for achieving optimal color reproduction.

Research in the field of color reproduction continues, and this contributes to the further development of television systems and video applications of a new level. Modern technologies make it possible to achieve better and better quality of color reproduction, which provides a more immersive and satisfying visual experience for viewers.

The assessment of the properties of color perception is presented here for monochromatic colors in the form of an assessment of the change in the position of the points of the line of spectral and purple colors with a change in the brightness of the stimulus and the brightness of adaptation in the color space of the color perception model CIECAM02.

2. Technologies and methods of creating an application for color perception

CSS is a special page style language used to describe the appearance of HTML documents. Along with HTML, CSS is a fundamental technology when building websites, so it is impossible to do without them when building a modern web application. When creating web applications, various CSS frameworks are usually used, one of which is Bootstrap.

Bootstrap is a free open source CSS framework used to create websites and web applications with responsive design. Bootstrap includes a variety of CSS and HTML templates for navigation, buttons, forms, and other interface elements. It simplifies the development of dynamic websites and web applications.

Switch to using the Bootstrap framework: Save time on application design development; Adaptability; Cross-browser compatibility

Disadvantages: Templates; Older browsers may display styles incorrectly.

PHP is a technology from Microsoft that is designed for building various web applications: from small sites to large web portals. Unlike the PHP Framework, PHP is an open source framework and can also run on top of the cross-platform .NET CORE, which can be deployed on Windows, Mac OS, and Linux.

PHP is a modular framework, meaning the user can only use specific modules of the framework by downloading them using the NuGet package manager.

Despite the fact that PHP is a newer framework than the PHP Framework, and is built on a new technology stack, PHP shares many similarities with PHP MVC, which combines the functionality of MVC, Web API, and Web Pages. In previous versions, these technologies were implemented independently of each other and therefore contain the same functionality, which is now combined into one PHP MVC program model.

Switch to using the PHP framework: Single solution for user interface and web API development, Ease of testing, Open source code, Cross-platform.

Microsoft SQL Server is one of the most popular DBMS in the world. It can be used for a wide variety of projects: from small applications to high-volume projects. SQL Server is developed by Microsoft Corporation. For a long time, this DBMS was exclusively for Windows, but starting with version 16, it became available for Linux as well.

MS SQL uses a relational model to organize databases. This model of databases was developed back in 1970 and today is the standard for organizing databases. The implementation model involves storing data in the form of tables consisting of rows and columns. Each row stores information about one object, while the columns hold the attributes of that object. To identify each row within one table, a primary key is used, which can be one or more columns. Using the primary key, you can refer to a certain row in the table, and accordingly, two rows should not have the same content of the primary key column.

With the help of keys, one table can be connected to another, that is, a connection can be organized between two tables, and the table itself can be presented in the form of relations (relation).

The language used for queries in MS SQL Server is Transact-SQL. Transact-SQL is an implementation of the ANSI/ISO standard for structured SQL query language with extensions. It is used both for small and medium-sized databases, and for large enterprise-scale databases. It has successfully competed with other database management systems for many years.

Switch to using MS SQL Server: Performance; Reliability and security; Ease of learning; Cross-platform; Ease of use with PHP;

IntelliJ IDEA - IDE can be downloaded and used for free. It has layouts for creating UI, which is usually where work on an application begins. Studio includes tools for developing solutions for smartphones and tablets, as well as new technology solutions for Android TV, Android Wear, Android Auto, Glass and additional contextual modules.

The Android Studio environment is intended for both small teams of mobile application developers (even in the number of one person) or large international organizations with GIT or other similar version control systems. Experienced developers will be able to choose the tools that are most suitable for large-scale projects. Android solutions are developed in Android Studio using Java or C++. The Android Studio workflow is based on the concept of continuous integration, which allows you to immediately identify existing problems. Long-term code review provides an opportunity for effective feedback from developers. This option allows you to publish the mobile version of the application in the Google Play App Store faster. For this, there is also support for LINT, Pro-Guard and App Signing tools.

With the help of performance evaluation tools, the status of the application package file is determined. Visualization of the graph lets you know if the application meets Google's benchmark of 16 milliseconds. With the help of the memory visualization tool, the developer will know when his application will use too much RAM and when garbage collection will occur. Battery analysis tools show you what kind of load your device is using.

Android Studio is compatible with the Google App Engine platform for rapid cloud integration of new APIs and features. In the development environment, you will find various APIs such as Google Play, Android Pay, and Health. There is support for all Android platforms, starting with Android 1.6. There are variants of Android that are significantly different from the version of Google Android. The most popular of them is Amazon Fire OS. In Android Studio, you can create APKs for this OS. Support for Android Studio is limited to online forums.

I chose JAVA as the programming language because it is one of the most relevant programming languages in general and also the most popular in the world of Android mobile application development. The combination of Android Studio and JAVA is currently the most common, high-quality and convenient for developers around the world. The programs created using it can work on various software and hardware platforms: from powerful business servers to smartphones and tablets.

Java development for Android uses not only Java classes that contain code, but also XML manifest files that provide the system with basic information about the program, and automatic build systems Gradle, Maven or Ant, in which commands are written in Groovy, POM languages and XML respectively; By default, Gradle is used in projects, and at the initial stages of learning Java development, you will not have to edit files written in Groovy. The XML language is also usually used for the layout of the UI part.

Working with the Java programming language requires high competence. As with any object-oriented language, it has many features and pitfalls that lead to errors in the operation of the mobile application. It is necessary to take into account these nuances and subtleties when developing a mobile application on Android. Features of the Java program code are readability and structure, the presence of accepted standards for its design.

3. Description of the functionality of the mobile application

Android Studio surpasses competitors in many parameters, which include: 1) flexibility of the development environment; 2) a larger set of functions; 3) development process that adapts to the developer.
When creating applications and utilities for the Android operating system, the software user can observe changes in the project in real time.

Among the features of the IDE, you can highlight the built-in emulator, which allows you to check the correct operation of the program on devices with different screens and different aspect ratios. This function became especially relevant after entering the smartphone trends, where screens with an aspect ratio of 18:9 are installed.

A distinctive feature of the emulator is viewing approximate performance indicators when running the program on the most popular devices. The development environment for Android Studio applications in the latest version has become really convenient even for novice developers. The program implements all modern tools for code packaging and marking. The Drag-n-Drop function, which is requested by many software authors, facilitates the transfer of components to the development environment directly. Localization of applications becomes much easier with the SDK feature, which is also included in the list of advantages of Android Studio.
List of benefits of the utility:

1) the development environment supports work with several programming languages, the most popular of which are C/C++, Java;
2) a code editor that is convenient to work with;
3) allows you to develop applications not only for smartphones/tablets, but also for portable PCs, Android TV set-top boxes, Android Wear devices, new-fangled mobile devices with an unusual screen aspect ratio;
4) testing the correctness of the operation of new games, utilities, their performance on one or another system takes place directly in the emulator;
5) refactoring of the finished code;
6) a fairly large library with ready-made templates and components for software development;
7) development of the program for Android N - the latest version of the operating system;
8) preliminary check of the already created application for errors in it;
9) a large set of tools for testing each element of the program, games;
10) for inexperienced/beginner developers, a guide for using Android Studio has been specially created, which is posted on the official website of the utility.

Disadvantages of the utility:

1) despite the presence of a built-in Android emulator in the development environment, problems may arise with testing the developed application. So, for its launch, a fairly large hardware base of the PC on which testing is planned is required;
2) another drawback is the impossibility of writing server projects in Java for PCs and Android devices.

Conclusion:
Android utility and app development software really makes a good first impression. Android Studio will be appreciated by both an experienced developer and a beginner who is just learning the basics. A rich set of tools, flexibility in development, testing capabilities, support for several programming languages and a built-in emulator make the utility one of the best in its niche.
The main advantages of JAVA:

1) the main advantage of Java is support for the concept of object-oriented programming (OOP). It allows you to write separate and reusable software components, building a strict hierarchy of programs;
2) java comes with an open-source library of design patterns, and enables the use of best practices that adapt to the development of server-side, desktop, embedded, and mobile applications;
3) cross-platform - Other programming languages are to one degree or another tied to the functions of software and hardware platforms, but Java's slogan says: "Write once, run anywhere." Cross-platform helps spread the language. Since 1990, Java has been used as a platform for developing mobile applications and is still one of the most popular programming languages in this field;
4) community support. The Java community helps programmers solve problems. For example, the Stack Overflows question forums and other user groups provide extensive support on a variety of topics;
5) availability of powerful tools. Java is supported by many popular IDEs, including Eclipse, NetBeans, and Jet Brains. Tools like Eclipse and NetBeans have played a crucial role in making Java one of the best programming languages for mobile development.

A solid set of tools not only helps with coding, but also allows you to influence debugging, which is necessary to eliminate errors during the development process. The integrated environment has made Java development much more convenient and faster. When using an IDE, it's easy to search, read, and refactor code.

Another important reason for the popularity of Java is the high return on investment invested in the development of a mobile application.

The world market is full of mobile applications written in JAVA. Bright examples of very popular applications are: Spotify, Twitter, Opera Mini, Nimbuzz Messenger, CashApp and others
Disadvantages of JAVA:

1. it is a rather complicated language in terms of syntax, which increases the probability of errors and bugs;
2. java developers face problems when developing applications based on the Android API due to certain limitations in the code;
3. requires more memory compared to Kotlin programs.

Conclusion:
Java is considered the fundamental programming language for Android. It also allows developers to write code that works seamlessly across multiple mobile platforms. In the real world, there are Java applications in various industries such as gaming, instant messaging, music streaming, and commerce.

1. Visualization of the process itself. The purpose of this section is to visualize the development process and explain the key aspects of each stage.
2. Code Screenshots: I'll start by presenting a series of screenshots that demonstrate the key pieces of code used in our project. For each code screenshot, I will provide a clear description, explaining exactly what is shown in the screenshot and how it relates to our project.
3. Screenshots of the results: After each screenshot of the code, I will present a corresponding screenshot of the result, which displays the functionality of the application related to the analyzed piece of code.
4. Analysis and explanation: At each stage, I will explain how the code works and how it affects the final result. I will review the key functions and classes, describe their purpose and role in the overall operation of the application.

A structured explanation of key aspects of the development and operation of our project, walking step-by-step through the code and its results to better illustrate the development process and the results obtained during the work on the project.
In this code, we create an initMap() function that is responsible for initializing the Packing circles on the web page.

1. mapOptions: we create an object with circle options, including zoom options, circle center coordinates (center), and circle styles (styles), which define colors and other visual options.

2. mapElement: we get a reference to the DOM element with the id 'map' where the map will be displayed.
3. map: We create a new instance of Google Maps by passing it the mapElement DOM element and the mapOptions circles parameter.
4. window.addEventListener('load', function() { initMap(); }): After the page is loaded, we add an event handler that calls the initMap() function to initialize the circles.

This code snippet demonstrates creating Packing circles on a web page with defined parameters, style, and coordinates.

1. rectangleCoords: we create an array of coordinates of the rectangle vertices in the form of objects with lat (latitude) and lng (longitude) properties.
2. rectangle: We create a new rectangle-shaped polygon using the google.maps.Polygon object. We set such polygon parameters as the coordinates of the vertices (path), stroke color (strokeColor), stroke opacity (strokeOpacity), stroke thickness (strokeWeight), fill color (fillColor), fill opacity. (fillOpacity), the map on which the polygon (map) is located, which can be dragged and edited.
3. createPolygon: we create the createPolygon function, which receives the coordinates of the vertices (coords), the map on which the polygon is located (map), and the fill color (fillColor). The function returns a new polygon with the specified parameters.

This code snippet demonstrates the creation of a rectangle and functions to create polygons in Packing with given parameters.

The next step will be dividing the polygon into 6 equal polygons.

Page development process

1. polygonColors: We create an array of colors that will be used to paint polygons.
2. polygons: we create an array of arrays of coordinates of polygon vertices. The initial training ground is divided into 6 parts.
3. Using the forEach method, we iterate through each array of polygon vertex coordinates and array index. In the middle of the cycle, for each set of coordinates, we call the createPolygon function, passing the coordinates of the vertices, the map and the fill color from the polygonColors array at the appropriate index. This is how we create and color polygons on a circle.

In this code snippet, we create a token for the tomato plantation on the Packing circle and add an information window with details about the plantation.

1. tomatoCoords: We set the coordinates of the marker for the tomato plantation in the red polygon.
2. tomatoIcon: We create an object with icon properties for the marker (image URL and size).
3. tomatoMarker: We create a new marker on the circle with the specified coordinates, icon and title.
4. tomatoInfoWindow: We create an information window for a tomato plantation with content containing information about the variety and size of the plantation.
5. Add the "click" event for the tomato plantation marker. When the user clicks on a marker, an information window opens on the circle next to the marker.

This code snippet demonstrates creating a marker for a tomato plantation on the Packing circle, displaying the marker's icon, and adding an information window with details about the plantation that opens when the marker is clicked.

So, as we did events for tomatoes, we do this code for each of our elements (cucumbers, wheat, pumpkins, and pears).

In this code snippet, we create markers for the tractor and the two harvesters on the Packing circle and add info boxes with details about each.

1. tractorIcon, Combine1Icon, Combine2Icon: We create objects with icon properties for markers (image URL and size).
2. tractorMarker, Combine1Marker, Combine2Marker: We create new markers on the circle with the specified coordinates, icons and titles.
3. tractorInfoWindow, Combine1InfoWindow, Combine2InfoWindow: We create information windows for tractors and combines with content containing brief information about each of them.

Add "click" events for tractor and combine markers. When the user clicks on a marker, an information window opens on the circle next to the marker.

This code snippet demonstrates creating markers for a tractor and two harvesters on the Packing circle, displaying the marker icons, and adding information windows with details about each that pop up when the markers are clicked.

Development of the navigation menu. This code fragment creates a mouse marker on the Packing circle and animates its movement along the specified path.

1. ratIcon: We create an object with icon settings for the mouse marker (rat.png file icon and its size).
2. ratMarker: Create a mouse marker with position, map, icon and title.
3. ratInfoWindow: We create an information window with the appropriate text.
4. ratPath: Array of coordinates for mouse movement.
5. ratMarker.addListener: We add the "click" event for the mouse marker so that an information window opens when the marker is clicked.

We start the animation of the mouse movement using the animateCombineMarker function created in the previous example, passing it the mouse marker and the path of movement.
This code snippet demonstrates creating an animation of the movement of the mouse pointer on the Packing circle according to the given path.
In this topic, we looked at an application that creates an interactive Packing map with markers and motion animation. The application includes the following elements:

1. Creation of markers for various objects (tomato plantation, tractor, harvesters, mouse), each with its own icon and information window.
2. Setting arrays of coordinates for the movement of the tractor, combines and mouse.
3. The animateCombineMarker function for creating an animation of the movement of markers along the specified paths.

Starting the animation of the movement of the markers on the Packing circle.
Detailed description of the code:

- Creating markers with appropriate icons, position and headings.
- Creation of information windows with text describing each object.
- Adding "click" events for markers to open information windows when clicking on markers.
- Specifying arrays of coordinates for animation of movement of various objects.
- The animateCombineMarker function for animating the movement of markers, which uses recursion and timeouts to change the position of the marker on the circle.
- Starting the animation of marker movement using the animateCombineMarker function.
- Thanks to this application, the user can visually observe the location and movement of various objects on the Packing circle, receiving additional information about them from the information windows.

4. Conclusion

Creating the Ishigari test in JavaScript (JS) is an important step in the development of web applications for testing visual skills. Below are some possible conclusions that can be drawn about building the Ishigari test on JS:
JS is a powerful programming language for creating web applications: JS has a wide range of functionality and can be used to develop a variety of web applications, including tests of visual skills such as the Ishigari test.
Need to use graphics libraries: To create an Ishigari test that requires visual representation of colors and numbers, it may be necessary to use graphics libraries such as HTML5 Canvas or CSS to manipulate images and colors.
Random sequence generation: Since the Ishigari test involves a random sequence of colors and numbers, it is necessary to use the built-in random number generation functions in JS to generate different combinations for each test.
User interaction requirements: The Ishigari test also requires the user to respond to certain colors or numbers. This can be implemented using JS event handlers that track user actions such as clicking a button or entering data.
Validation of answers: After the user completes the test, their answers must be verified. This can be done by comparing the entered data with the correct one.

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