Mobile Application for People Suffering from Color Blindness

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Abstract—The article describes the method of developing a mobile application, including a comparison of analogues, an algorithm for writing the key function of the application, the principle, demonstration and explanation of the application. The relevance of this application and the scope of its application are also proved. A description of the characteristics of the application has been made, which can be individually configured for each user. The application modes listed in the paper are selected by the neural network based on the optimal and most suitable option for a given situation, and it can also combine them. The application also contains libraries of settings for each type of color blindness.

Keywords - mobile application, programming, color blindness, development, Java programming language, Android Studio

I. INTRODUCTION

Color blindness or color blindness is a pathology of vision in which a person loses the ability to fully or partially distinguish colors [1]. This problem is extremely relevant at the moment. Color blindness or color vision deficiency affects about 1 in 12 men (8%) and 1 in 200 women worldwide. There are about 300 million colorblind people on Earth (about 4.5% of the total population), most of whom are men. For a person diagnosed with color blindness, there are a number of restrictions that are imposed on the choice of profession. So, with a violation of color vision, it is impossible to master the specialty: chemist, surgeon, pilot, sailor, railway worker. A number of military specialties are banned. The vast majority of people with poor color vision have a genetic condition that is incurable.

The foregoing indicates the relevance of the problem under consideration, which has an engineering solution. This paper discusses in detail the development of a special mobile application aimed at solving this problem.

The relevance of the demand for mobile applications is due to the fact that almost half of the world's population already has smartphones, and the second half is likely to acquire them in the near future - therefore, the target audience of mobile application manufacturers will constantly grow [3].

Table I . Comparison of mobile applications "Vision of color" and "Color Blind Pal" [4], providing assistance to people suffering from color blindness

	Mobile app name	
	Vision of color	**Color Blind Pal**
Informing the user what the app is for	Available	Absent
Work stability	The application was created for the new version of Android, so it works stably on new devices, but may not work on devices with an old version of Android	Cannot work stably on new devices with new Android versions, app crashes suddenly, bugs occur that cause functions to work incorrectly
App support	The application is maintained, developed, updates are taking place	The application has been discontinued, last updated on March 8, 2017
Ease of use and ease of learning	The application has an intuitive interface that is easy to understand even for non-Russian-speaking users	The application has a complex confusing interface that is difficult to understand.

13. Functionality	The functions of the application are performed with the highest quality. The application gives an accurate undeniable result. The result given out by application, practically does not depend on illumination of an object. It is possible to quickly switch from the mode of color perception of the world to the application cameras to capture the object of interest to the user. The application gives the result in real time, and the result is visual, that is, the user can see the object recolored by the application in real time in the part of the color spectrum visible to the user, so that the user can distinguish objects of one color from others in real time. The app has fewer features compared to Color Blind Pal.	The application has more features compared to Vision of color. The application does not allow you to get an accurate result, as it depends on the illumination of the subject. The operation of the application is structured as follows, the color of one pixel of the image is read from the camera, then the name of the color that this pixel has is displayed to the user on the screen. The disadvantage of this method is that if the object is poorly lit, it will be difficult to know the real color of this object, since its real color will be obscured by black. Also in the application there is a function for filling objects that have a red color with blue, but this filling is not transparent because of which the texture of the object is invisible, only its outline is visible, that is, the outline of the object and this mode can be turned on only for red, and for green and blue is not allowed. Just as importantly, the app lacks a feature that allows the user to take a photo of an item.

II. DESCRIPTION OF THE METHOD FOR SOLVING THE RESEARCH PROBLEM

The mobile application, the development of which is considered in this study, was given the name "Vision of color". This mobile application has an analogue - this is the Color Blind Pal application [4] developed by Vincent Fiorentini. Table 1 provides a comparison of these applications, taking into account the main functions that the application should perform. The uniqueness of the Vision of color application lies in obtaining accurate and visual results in real time, as well as in ease of learning, ease of use and the ability to photograph an object visible to the user.

For a mobile application, the development of which is considered in this study, the creation of color perception modes of the world using the example of a color perception mode for green will look like this.

Table II. Code of the mode of color perception of the surrounding world for green color with an explanation

Line number	**Code**	**Code Explanation**
1.	`imageAnalysis.setAnalyzer(ContextCompat.getMainExecutor(MainActivity4.this),`	Adding an analyzer class that contains the code of operations performed with the image received from the camera
2.	`new ImageAnalysis.Analyzer() {`	By entering this line, we create a new image analyzer. Entering this line creates lines 3 and 4
3.	`@Override`	We get an object of type "ImageProxy" from where we can extract image data
4.	`public void analyze(@NonNull ImageProxy image) {`	
5.	`Image img = image.getImage();`	Getting the image
6.	`Bitmap bitmap = translator.translateYUV(img, MainActivity4.this);`	We perform the conversion of the original image into a “Bitmap” pixel map, that is, an array containing the pixels obtained from the image with which you can perform various transformations
7.	`int size = bitmap.getWidth() * bitmap.getHeight();`	Set the size of the array with pixels
8.	`int[] pixels = new int[size];`	We get the pixels of the image into an array of the specified size
9.	`bitmap.getPixels(pixels, 0, bitmap.getWidth(), 0, 0,`	Copying an array with image pixels to a pixel map
10.	`bitmap.getWidth(), bitmap.getHeight());`	
11.	`for (int i = 0; i < size; i++) {`	Looping through an array

<table>
<tr><td>12.</td><td><code>int color = pixels[i];</code></td><td>Getting color</td></tr>
<tr><td>13.</td><td><code>int r = color >> 16 & 0xff;</code></td><td>Getting the red color from the image separately</td></tr>
<tr><td>14.</td><td><code>int g = color >> 8 & 0xff;</code></td><td>Getting the green color from the image separately</td></tr>
<tr><td>15.</td><td><code>int b = color & 0xff;</code></td><td>Getting the blue color from the image separately</td></tr>
<tr><td>16.</td><td><code>int red = r;</code></td><td>Assign the red color to the variable "red"</td></tr>
<tr><td>17.</td><td><code>int green = g / 0x999999;</code></td><td>We assign the green color to the variable "green", recolored to a shade of gray using the formula "g / 0x999999", where "0x999999" is a shade of gray. You can see color encodings in hexadecimal code on the website [12]</td></tr>
<tr><td>18.</td><td><code>int blue = b;</code></td><td>Assign blue color to "blue" variable</td></tr>
<tr><td>19.</td><td><code>int black = 0xff000000;</code></td><td>Assign the variable "black" the black color "0xff000000"</td></tr>
<tr><td>20.</td><td><code>pixels[i] = black | red << 16 | green << 8 | blue;</code></td><td>We write the result to the array with index "i". We write the black color "black" or "|" to the array red color "red << 16" or "|" grayscale recolored green "green << 8" or "|" blue color "blue" at the end of the line we put a semicolon, which indicates the end of the line ";"</td></tr>
<tr><td>21.</td><td><code>}</code></td><td></td></tr>
<tr><td>21.</td><td><code>bitmap.setPixels(pixels, 0, bitmap.getWidth(), 0, 0,</code></td><td rowspan="2">We write the transformed pixels of the image to the pixel map</td></tr>
<tr><td>22.</td><td><code>bitmap.getWidth(), bitmap.getHeight());</code></td></tr>
<tr><td>23.</td><td><code>preview.setRotation(image.getImageInfo().getRotationDegrees());</code></td><td>We send the resulting pixel map to the "imageView" element that displays the resulting image on the application screen. In order for the resulting image not to be inverted, enter the parameter "setRotation(image.getImageInfo().getRotationDegrees())" that sets the rotation of the resulting image</td></tr>
<tr><td>24.</td><td><code>preview.setImageBitmap(bitmap);</code></td><td>Displaying a correctly upside down image on the application screen</td></tr>
<tr><td>25.</td><td><code>image.close();</code></td><td>We finish working with this image and feed a new image to the analyzer input</td></tr>
<tr><td>26.</td><td><code>}</code></td><td></td></tr>
<tr><td>27.</td><td><code>});</code></td><td></td></tr>
<tr><td>28.</td><td><code>cameraProvider.bindToLifecycle(MainActivity4.this, cameraSelector, imageAnalysis);</code></td><td>We launch the written script of the analyzer for execution</td></tr>
</table>

III. APPLIED INTERPRETATION AND ILLUSTRATION OF OBTAINED RESEARCH RESULTS

Based on the results of the study, a mobile application was developed that can help people with color blindness.

The algorithm of the developed mobile application will look as follows.

After installing the application, its name and logo will be displayed on the smartphone screen.

Fig.1 Application name and logo

After entering the application, the main screen of the application will be displayed, welcoming the user and explaining to him the purpose of this application, which is shown in Figure 2. Then, after pressing the "START" button, the transition to the screen for selecting modes of color perception of the surrounding world is performed.

Fig. 2 App home screen

The mode selection screen displays the object received from the camera (Figure 3(a)). This function will allow the user to see the object that will be photographed using the "Camera" button in the camera application (Figure 3(b)) or view this object in the color perception modes, the function is implemented by the "R", "G" or "B" buttons. Under the names of the modes, that is, under the names of colors, there are colors corresponding to the names (R - red, G - green, B - blue). Below the names with colors, they are assigned shades of gray, in which red and green colors will be repainted. The blue color is assigned a shade of gray that only a person with color blindness will see.

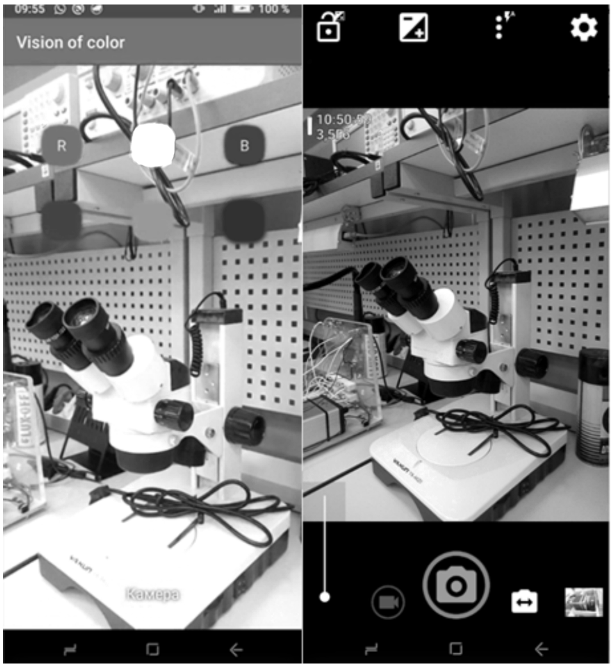

Fig.3 Displaying the object received from the camera

To explain how the modes work, the application "Sim Daltonism" was used, which allows you to see the world as people with color blindness see it.

In Figure 4, you can see how red and green colors on a laptop screen are seen by a person with healthy vision, that is, red is on the left, and green is on the right.

Figure 5 shows how these colors are seen by a person with color blindness, namely with protanopia, that is, not seeing red. That is, red, located on the left, a person with protanopia will see as green. Thus, it turns out that this person will not be able to distinguish red from green, since he sees both of these colors as green.

The question arises as to whether it is possible to distinguish these two colors from each other. It is this task that the mobile application “Vision of color” developed in this study solves, which helps people suffering from color blindness to distinguish colors that seem the same to them. In Figure 6, you can see how the application recolors the red on the left into a shade of gray, so that a person with color blindness can distinguish it from the green on the right.

Fig.4 Visibility of red and green in a person with healthy vision

Fig.5 Visibility of red and green in a person with protanopia

Fig.6 Recoloring red to a shade of gray

The color perception mode for green works in a similar way. Figure 7 - how a person with healthy vision sees this image (green box on the left, red on the right). Figure 8 - how a person suffering from color blindness sees this image, namely deuteranopia, that is, not seeing green (red box on the left and right). Figure 9 - how the application helps to distinguish colors from each other (on the left is a gray (recolored green) box, on the right is red).

Fig.7 Image of a person with healthy vision

Fig.8 Image of a person suffering from color blindness

The color perception mode for blue works a little differently. The application does not recolor the blue color into a shade of gray, but makes the blue color more vivid and saturated. It works this way because a person with color blindness, namely tritanopia, sees blue as a shade of gray, and so that the shades of gray that the application gives out and the person with color blindness sees differ, the application makes the blue color brighter and more saturated, which results in a lighter shade of gray than that shade of gray that a person suffering from color blindness sees in life. Figure 9 - how a person with healthy vision sees this image (blue case on the left, gray case on the right).

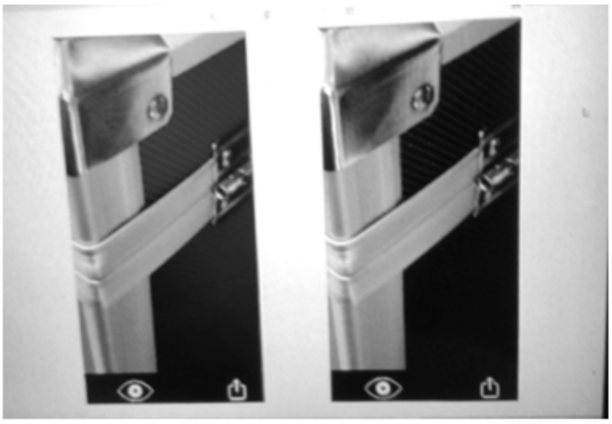

Fig.9 Image of a person with healthy vision

Figure 10 - how this image is seen by a person suffering from color blindness, namely tritanopia (gray case on the left and right). Figure 11 - how a person suffering from color blindness will see the image issued by the application and how he will be able to distinguish colors from each other. Based on the fact that the case on the left is light gray, we can say that it is blue, and the case on the right is gray.

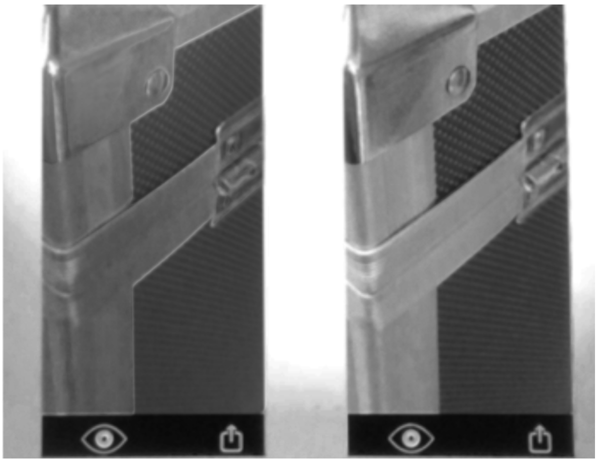

Fig. 10 Image of a person suffering from color blindness

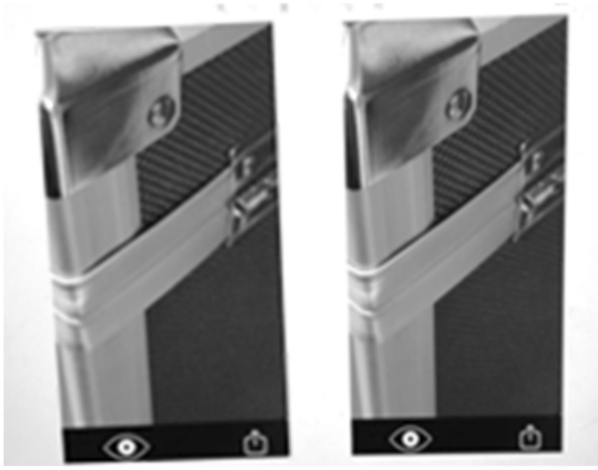

Fig.11 Differentiate colors for a colorblind person using an app

IV. CONCLUSION

Based on the results of the study, a mobile application "Vision of color" was developed in the Java programming language, which helps people with color blindness. This application can be used in various industries, such as: in the classroom at school (university) when performing tasks requiring work with illustrative material (maps, atlases); in the work of a graphic designer in the development of graphic design of sites (programs); in the work of a chemist, when mixing various substances; upon obtaining the right to drive a vehicle; in the work of an electrician; in robotics when creating robots from parts and wires of various colors that have their own semantic meaning on diagrams and in other areas.

Thus, the developed application allows to significantly improve the quality of life of people with color blindness, to navigate the world around them. As a result, favorable conditions are created for full-fledged professional realization in various spheres of human activity, as well as a socio-cultural aspect that allows them not to feel limited in their abilities, and to see the world as a person with healthy vision sees it.

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