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A NEW APPROACH TO GENERATING PSEUDOISOCHROMATIC PLATES

ABSTRACT *Pseudoisochromatic plates have been used for detecting dichromacy (especially protanopia and deutanopia) for almost a century. This method, although widespread due to its simplicity and relatively low examination cost, is often criticized because of potential ambiguity and inaccessibility for certain groups of patients. In this article author analyzes different versions of currently used pseudoisochromatic plates and introduces a tool for generating customized plates in order to detect different types of dichromacy in certain user groups.*

Keywords: *color vision disorder, pseudoisochromatic plates, color vision, computer aided diagnosis.*

1. INTRODUCTION

Having color vision disorder may prevent a person from engaging in certain occupations, especially when color recognition is either important for safety or essential for the work itself [9]. Those limitations are often introduced by law [9], although may differ in severity. In some countries colorblind are not

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permitted to apply for driving or sailing license at all [7], while in other (e.g. Poland [1]) the injunction applies only to professional qualifications.

In most cases, a colorblind person can live normal life, as only color vision, not vision itself, is distorted [5]. Many people are not even aware of their impairment, as it can be detected usually only on few occasions: during pre-school medial tests or while applying for driving license [2]. But even then colorblindness can be not detected e.g. due to the error of the examiner or the examining method [8]. In some cases, the wrong result of this examinations can be two-fold: either a colorblind person is allowed to apply for e.g. driving license (normally being not allowed to) or (more rarely) a person with normal color vision is not permitted to do so. This situation is not acceptable in both mentioned cases. The error rate of the method used for colorblindness detection should be minimal, especially concerning the method used in countries with strict legal regulations regarding the colorblind.

2. TYPES OF PSEUDOIZOCHROMATIC PLATES AND THEIR USAGE

The first medically used pseudoisochromatic plates were introduced in 1917 by Japanese ophthalmologist Shinobu Ishihara [6].

So-called Ishihara plates contain a circle of dots which seem to be random in both color and size, forming a number visible for people with normal color vision, but invisible (or at least hard to see) for colorblind [6]. The original set consisted of 38 plates designed mainly for red-green color deficiencies (both protanopia – caused by the complete absence of red retinal photore-ceptors [7] and deutanopia, which is caused by the complete absence of green retinal photoreceptors [7]), but some of the plates can also be used for testing blue-yellow color deficiencies. Typically the test is performed using printed sets, but web-based applications using predefined plates are also used [4].

Typically, there are five different types of plates in each set [10]:

- introductory – a plate used for explaining the testing process, with figure (e.g.) number visible to everyone;
- vanishing figure – with figure (e.g. number) easily read by people with normal color vision but unreadable for people with color vision impairment;
- hidden digit – with figure readable only to color defectives (so called reverse plate);

- transformation plate – with combination of two figures – one readable to people with normal color vision (e.g. number 74), while the other being readable only to colorblind (e.g. number 71);
- qualitatively diagnostic - vanishing plate that also permits differentiation between protans and deutans.

There are many different sets of pseudoisochromatic plates developed on the basis of Ishihara's work, although they are not as widespread as the original [10]. Some of the variations are quite interesting – for example in case of Handy-Rand-Ritter (often abbreviated to H-R-R) plates, which are used in United States, numbers are replaced with signs or geometric figures (e.g. square, circle, etc.) [3].

The examples of aforementioned pseudoisochromatic plates are presented in Figure 1 a-c.

a) b) c)

Fig. 1. Examples of pseudoisochromatic plates:
a) Ishihara plate (vanishing design), b) reversed Ishihara plate (hidden digit), c) H-R-R plate ([2])

Using pseudoisochromatic plates for detecting colorblindness (both using Ishihara plates and its variations) is widespread due to its simplicity and relatively low examination cost as one set of plates can be used for several years [10] and the new one can be printed using medium-class color printer [2].

Despite those advantages this method is often criticized because of its ambiguity (e.g. in the original set different answers to selected plates are accepted as correct, like reading whether 23 and 73 [10]) and inaccessibility for certain patient groups (children or foreigners) [5]. For example children at a certain development level may not be able to name the recognized numbers properly despite being able to recognize them. The same situation may apply to foreigners.

3. EyeConv – A NEW APPROACH TO GENERATING PSEUDOISOCHROMATIC PLATES

EyeConv is an application based on the following assumption – what if the set of plates was adjusted to the person being examined? For example, it may be troublesome for a child to name the numbers or geometric figure seen on a plate properly, but it should be relatively easy to name a characteristic shape (e.g. a fruit or animal). In some cases, the patterns on the plates should be adjusted to the limited linguistic abilities of the examined person, like in aforementioned cases of children or foreigners.

EyeConv allows user to convert almost any monochromatic bitmap into a pseudoisochromatic plate. The bitmap image should not be complicated, as the shape in the image may be obfuscated during the conversion. Canny edge detection is used for detecting the edges in the transformed image.

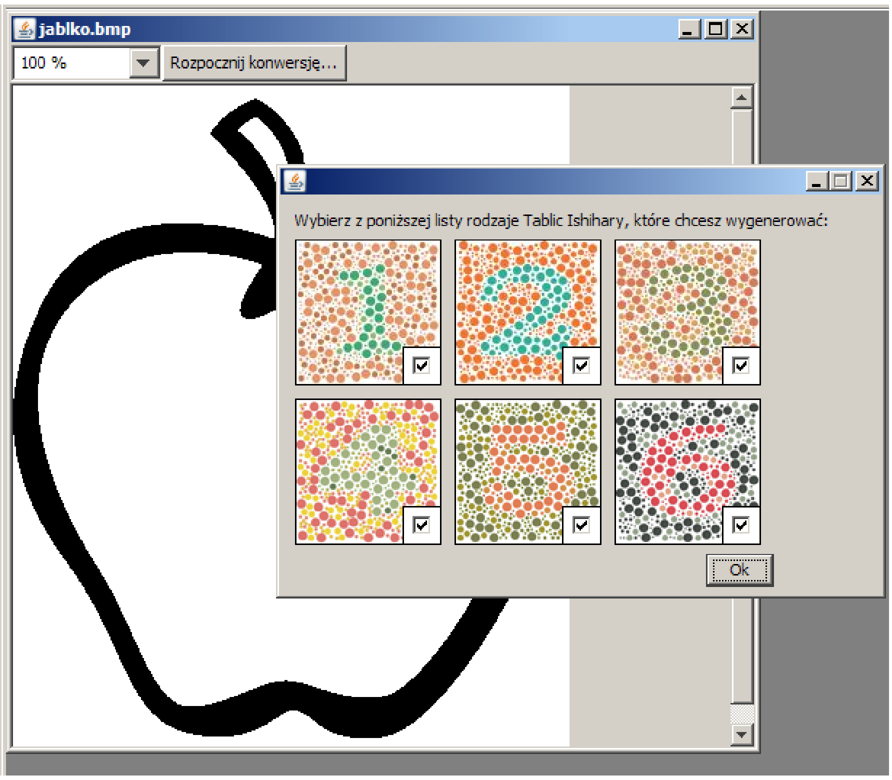

Fig. 2. Interface of the eyeConv application [source: own work]

Each plate is generated in six different color versions. This allows testing not only all types of dichromacy but also anomalous trichromacy. This differs from e.g. original Ishihara plates which are limited mainly to testing two types of dichromacy.

EyeConv allows its user to create their own sets of pseudoisochromatic plates, varying in detail level or difficulty, although at this level of application development it allows only creating vanishing design plates. This allows the color vision test to be flexible and adjustable to the needs of the patient, without using predefined and inflexible sets of plates, often developed decades ago.

The application interface is presented in Figure 2 and sample plates generated by eyeConv are presented in Figure 3 b-h.

EyeConv is developed by computer science students at Lublin University of Technology under the supervision of the author.

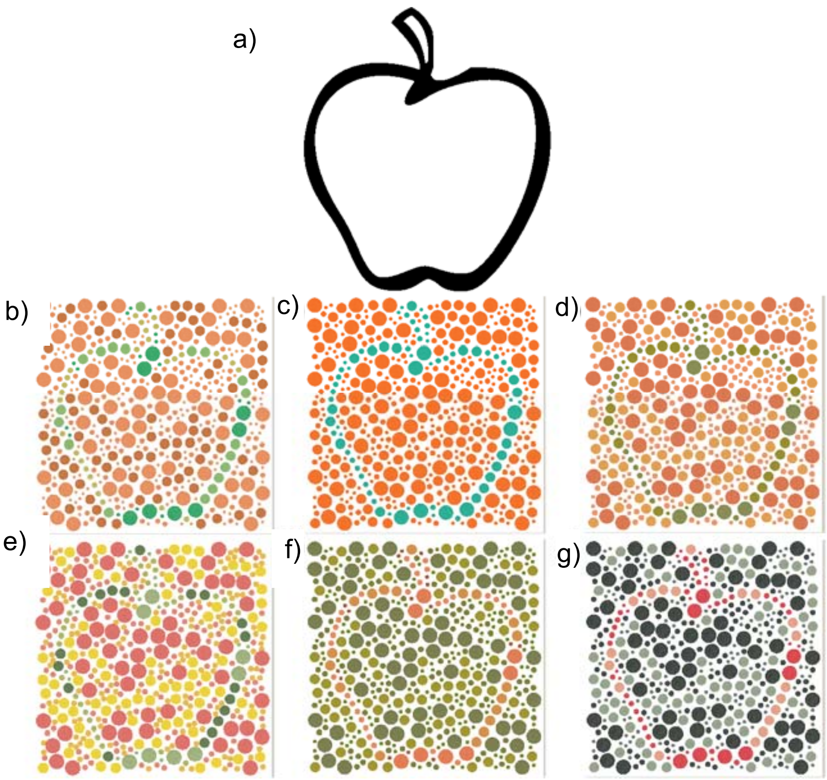

Fig. 3. Original image and plates generated by eyeConv [source: own work]:
a) original image, b-g) different color versions of pseudoisochromatic plates generated

4. CONCLUSIONS

The preliminary research conducted on a group of school pupils shows that the plates generated using eyeConv application have the same color-blindness detection ratio as standard Ishihara plates (the same group was tested using both methods).

Further research, involving different social groups (like smaller children or foreigners) is yet to be conducted. The mentioned preliminary results show that the presented method may be a valuable alternative to the standard pseudoisochromatic plates.

The author would like to emphasize that at the current level of application development all of the plates generated by eyeConv should be used only to detect potential colorblindness, as each diagnosis should be confirmed by further medical examination using methods more precise than pseudoisochromatic plates, such as amaloscope or lamp method.

LITERATURE

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STRESZCZENIE *Tablice pseudoizochromatyczne od prawie stulecia wykorzystywane są do detekcji dichromatyzmu (zwłaszcza protanopii i deutanopii). Pomimo wielu zalet – takich, jak choćby prostota i niski koszt badania – metoda ta jest często krytykowana ze względu na potencjalną niejednoznaczność uzyskiwanych wyników oraz niedostępność dla niektórych grup pacjentów. Poniższy artykuł omawia aplikację generującą tablice pseudoizochromatyczne dostosowane do diagnozowania konkretnego rodzaju zaburzenia widzenia barw oraz do konkretnego pacjenta. Przedstawione zostaną również wstępne wyniki badań.*

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