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Features of the Perception and Recognition of Images in Art: Review Article

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Abstract: ***This paper provides an review of some modern research areas in the field of perception and recognition of visual information. The articles on the features of the perception of works of art, the occurrence of neural responses in the brain, for different observers are considered. Studies on the analysis of eye movements, their influence on the process of perception and recognition of faces and emotions are described. Characteristic signs of eye movement when viewing modern web pages, the effect of the contrast effect and visual stimuli on people with color perception features are given. Articles are presented on recognition of images and scenes with computer vision, the creation of such systems for people with visual impairment, and the benefits of binocular vision. Articles on the study of the perception of visual illusions in the diagnosis of features and diseases of the brain are considered, some illusions are described.***

Keywords: perception, recognition, works of art, neural processes, brain, types of eye movements, methods for recording eye movements, contrast perception, color perception disorders, color blindness, recognition of objects and space, visual illusions.

1. Introduction

Visual information is dominant in everyday life. The use of recognition systems in various areas of life support of modern civilization is becoming commonplace. These systems provide both public safety and make the social environment more comfortable. The issues of perception and recognition of visual information have a long history of research. This review presents works within the framework of the original interdisciplinary concept, covering not only the technical aspects of implementation, but also the perception of visual information in the context of art. The article describes the features of the perception and recognition of works of art depending on the state of the observer, the influence of eye movement on this process, the recognition of visual stimuli that differ in color, by localization in space. The proposed concept can help in the analysis of the current state of research, and determine the contours of future development.

1.1 Visual Perception of Works of Art

Consider some of the modern works on the impact of works of art on visual perception. The work [1] is devoted to the conceptual problems of visual perception as applied to the field of art. The author is an artist, some of his paintings are presented in the work, on the example of which the phenomenon of perception of works of fine art is considered (Fig. 1). According to the author, science is based on rational descriptions, and art operates on artistic, aesthetic, philosophical concepts. The German scientist German von Helmholtz's statement regarding the perception of the surrounding space is mentioned: "the qualities of our sensations are projected onto objects in the surrounding space". They appear colored, red or green, cold or warm, smell or taste. Even understanding that these concepts are subjective and relate to the properties of our nervous system. Art can help us in understanding complex perceptual problems.

Figure 1: Author's paintings: "Gray on Orange", "Flower", "Drawing Drawing" [1]

According to the author, the perception of the real world and the perception of images of the real world are a very confusing problem that are associated with the concept of rationality. Researching these issues can help us make progress in understanding perception in the close relationship between art and modern scientific, intellectual breakthroughs.

In [2], the results of a study of the neuroelectric activity of the brain in the perception of a certain set of pictures are presented. The selected group of people with art education was presented with original (Original set), stylized paintings by Titian and a modern artist. Stylized paintings were obtained from the original ones by leaving color spots (Color set) and contour shapes (Style set) (Fig. 2). In the

front row is a picture of a contemporary artist L.D. Campana and its processed versions, and in the second row - a painting by Titian Vecellio and the corresponding processed analogues. Subjects were randomly exposed to the proposed stimuli.

As a result of the experiments, it was found that when viewing the first 10 seconds, the Original set evoked more emotions than other sets of paintings. The emotions caused by the Color and Style sets over time after 30 seconds intensified, however, for the first set of Original emotions remained stable. Throughout the experiment, evidence of cortical activity flow from the parietal and central regions to the prefrontal and frontal regions was revealed while viewing images of all data sets. This result is consistent with the idea that the active perception of images with stable cognitive attention in the parietal and central areas caused the formation of judgments about their aesthetic assessment in the frontal areas.

Figure 2: An example of three groups of stimuli tested in a study (Original, column A; Style, column B; Color, column C) [2]

It was found that various areas of the brain participate in the assessment of perceived stimuli, including not only the frontal, but also the motor and parietal cortical layers. It should be noted that the prefrontal dorsal cerebral cortex is selectively activated only by stimuli considered to be beautiful. Whereas, prefrontal activity is generally activated during the evaluation of both pleasant and unpleasant stimuli. The usefulness of the study lies in the fact that neuroelectric visualization can be used to obtain useful information related to the evolution of aesthetic judgment of people during the perception of images from simple stimuli to works of art.

The work [3] is devoted to the study of agnosia of visual objects to determine pathologies of the brain. Visual agnosia occurs when damage to the structures of the cerebral cortex responsible for the analysis and synthesis of information leads to a disruption in the process of perception, recognition of visual stimulus. The modern ideas about the neuroanatomical and neurophysiological basis of the visual process are described. Clinical cases of agnosia of visual objects, features of neuropsychological diagnosis and rehabilitation of patients are given.

For testing, we used visual objects of various origins: images of objects, geometric shapes, letters, words, and faces with different emotional expressions. The basic testing models were based on modified Wundt methods (Fig. 3 (a)), the Stroop method (Fig. 3 (b)), and Gottschald figures (Fig. 3 (c)). Types of errors, response time and detection were measured, and recommendations were made for the diagnosis of visual agnosia in medical practice.

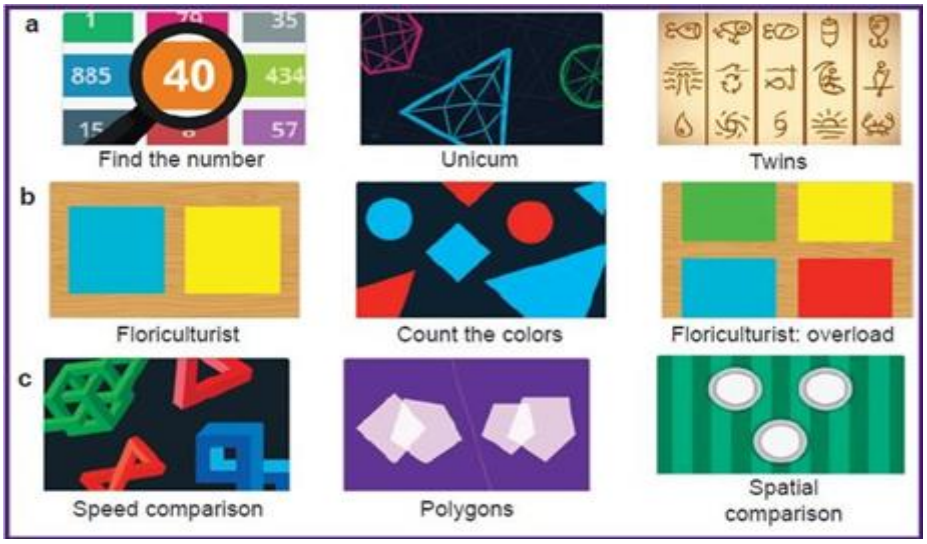

Figure 3: Examples of interactive implementation of basic test models: a) Wundt's method; b) Stroop test for mutual influence; (c) Gottschalde test [3]

The work [4] is devoted to the study of the visual perception of patients after surgery. The article describes the results of a study of the features of visual perception and cognitive processing of visual images in patients with coronary heart disease. One hundred and seven patients with an average age of 62 years took part in the study; it was shown that immediately after the operation, the ability to recognize fragmented images worsens (for example, the Landolt ring [5], Fig. 4). However, after three months, this ability is not only restored, but also exceeds the preoperative level. Moreover, patients who underwent surgery do better with the proposed tasks three months after surgery than patients undergoing conservative treatment.

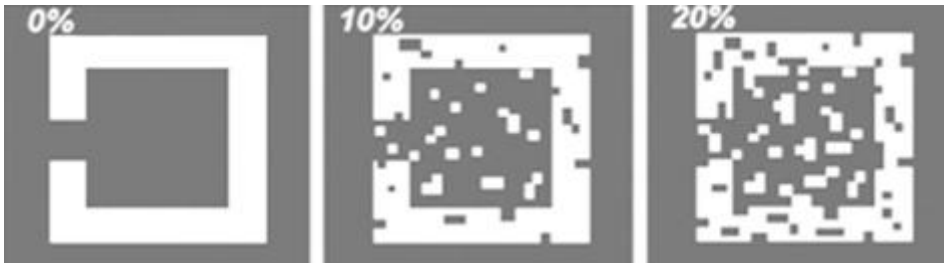

Figure 4: The stylized Landolt ring without noise and with different noise levels [4]

1.2 Types of eye movement and recognition

The article [6] gives a brief description of the types of eye movement and provides an analysis of methods and systems for recording oculomotor activity. Our eyes make micromotion, even if we look at the stimulus motionlessly, they cannot be controlled. Eight kinds of eye movements are generally known, which are attributed to micro- and macro-movements. Macro movements of the eyes are amenable to control; they characterize a change in the direction of view. These movements are divided into macroaccades caused by a sharp change in gaze direction, tracking movements in the form of smooth tracking of the stimulus, nystagmus - oscillating eye movements with tracking, vergent movements: convergence and dilution of the visual axes and torsion movements: rotational eye movements relative to the visual axis [5]. Micro movements are divided into tremor, drift and microaccades, rapid eye movement when changing fixation points.

Tracking methods can be divided into two groups: contact and non-contact. The first includes electrooculography, photo-optical and electromagnetic methods. To the second group: the photoelectric method and the video recording method. Recently, the video recording method has become more widespread, which is remote and includes two interrelated procedures: video recording of the subject's eyes and software for determining the direction of the gaze on each frame of the video sequence. The source of information about the direction of view is the pupil, sclera or corneal flare. Another type of video registration method involves highlighting the eye with a point source of infrared radiation and high-speed shooting with an infrared video camera. This method is used in Tobii devices. These gaze tracking devices include: Tobii REX, Tobii EyeX, Tobii TheEyeTribe [7].

Consider some modern articles on the study of oculomotor activity. The work [8] is devoted to the study of gaze fixation when viewing faces. Despite the fact that there are a lot of visual features on the human face, observers prefer to fix their eyes mostly on the eyes and mouth. This is explained to a greater extent by the evolution of social signs of recognition and communication in human society.

The data of experiments with 41 participants are presented when viewing four faces with different initial stimuli (Fig. 5). Blue ellipses on the face show the location of each

individual gaze fixation, and the size of each ellipse is proportional to the duration of fixation. For the face on the left side of Fig. 5, the degree of fixation of the gaze is presented in the form of a heat map. The degree of fixation of the look on the faces is a useful tool for assessing individual differences and subsequent recommendations in social communication.

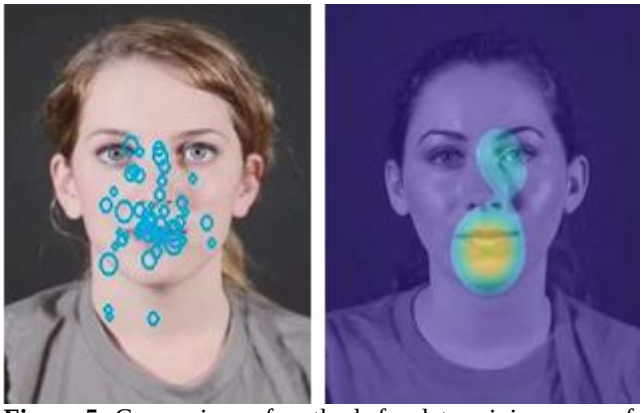

Figure 5: Comparison of methods for determining areas of interest and analysis of the main components [8]

The article [9] proposes a new method for analyzing eye movement during free viewing. The method is based on the fact that the eyes move from one object to another object in the visual scene. The method was applied experimentally on two monkeys monkeys freely viewing visual stimuli in the form of scenes with objects. Analysis showed that monkeys showed a behavioral shift from free viewing to focal processing of visual stimulus.

In [10], a study was conducted to determine oculomotor activity and expression perception, depending on the spatial orientation of the face. It is shown that 180 ° rotation of the face image leads to a decrease in the recognition efficiency of the intensity of emotions. In an inverted image, weak facial expressions are perceived as a calm state. This process depends on the modality of emotions and is complex non- linear. At the same time, “fear” and “grief” are worse recognized, and a calm expression is better and more stable. With an increase in the intensity of emotions in the directly located face image, the effect of left-side dominance is registered, in the inverted image the magnitude of the effect increases (Fig. 6). However, the dominance of the perception of weakly expressed expressions is right-handed.

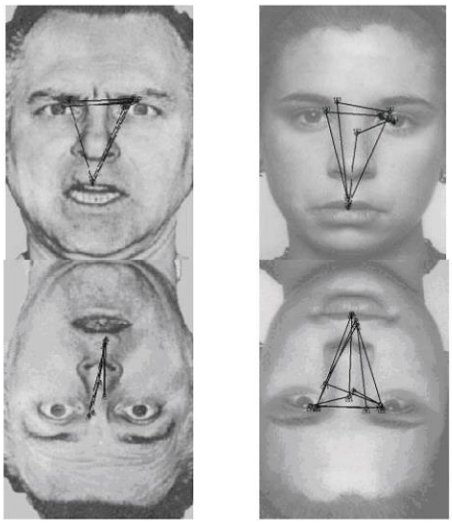

Figure 6: Examples of oculograms of different subjects in the perception of facial expressions in directly located and inverted images [10]

The work [11] is devoted to the study of oculomotor activity in face recognition. The experiment was attended by 32 people of Tuvan nationality who evaluated the similarity of the targets presented by couples using a 5-point scale. Target pairs of photographs of human faces, which were formed from two source photographs (Caucasoid and Asian type) and four transition photographs, were used as stimulus material. They were formed by morphing in increments of 20%. In the process of presenting stimulus material, oculomotor activity of subjects was recorded using EyeTribe eye tracker [7]. The relevance of these studies is due to issues of public safety, forensics and business communication.

Figure 7: Transitional series of face images from which target stimulus pairs are formed [11]

1.3 Web browsing, F-pattern

In [12], a study is presented on modeling the attention of users when browsing web pages. The paper proposes a saccadic model for studying dynamic visual behavior of people. A multilevel analysis of the signs of visual information is used and the probability of fixing the user's gaze is determined. Experimental results on tracking eye movements when browsing the web freely showed the effectiveness of the proposed method (Fig. 8).

a) *b)*

Figure 8: Comparison of the reliability assessment of a web page and saccade forecast, (a) a web page, (b) a heat map of gaze fixation [12]

1.4 Perception of contrast

Of the modern works in the field of contrast perception, we note a rather detailed review [13], which is devoted to the historical and philosophical aspects of brightness perception. Despite the fact that these issues have been studied for over two hundred years, the mechanism of action of some optical illusions is not fully understood. In the work, the neural mechanism of perception formation from visual receptors to the cerebral cortex is described on the basis of ascending processes. Internal test squares of the same brightness contrast with the gradient background (Fig. 9, left), the contrast effect also remains against the background of plain vertical stripes (Fig. 9, right).

The perception of brightness is proposed to be analyzed using two philosophical trends: idealistic and materialistic approaches. The theory of contrast is based on lateral inhibition, similarly to the basic laws of dialectics: the unity of opposites, the relationship, the transition of quantity into quality, the negation of negation.

Figure 9: Assimilation of brightness [13]

This is the basis for some modern research in experimental psychophysics and the application of mathematical modeling methods. The adequacy of such models requires the use of quantitative representations of complex mental processes based on the dialectical law of interaction between part and whole.

1.5 Color Blindness

The work [14] is devoted to the study of the phenomenon of color blindness, since up to 8-12% of men and 0.5% of the female population of European countries suffer from this violation of color perception. Therefore, there is a need to develop methods for modifying color digital images to improve their perception by people with visual impairment. The article specifically elaborates the development of image modification methods for color blind people of the primary category - protanopes (low sensitivity to red shades). Protanopes causing disturbances are distinguished into a separate color group, and images are corrected and adapted to their perception [15]. Image processing time is reduced by using color quantization. This method, with minor changes, can also be applied to other types of color vision impairment, to deuteranopes suffering from difficulties in distinguishing green shades.

Figure 10 above shows an example of an illustration based on dark shades of red and green. These shades are hard to see, especially in a small area of the image. I would like to note that also these shades have the same tonality in the gray version. In the center for updating perception, contrasting shades of blue, yellow and white are given.

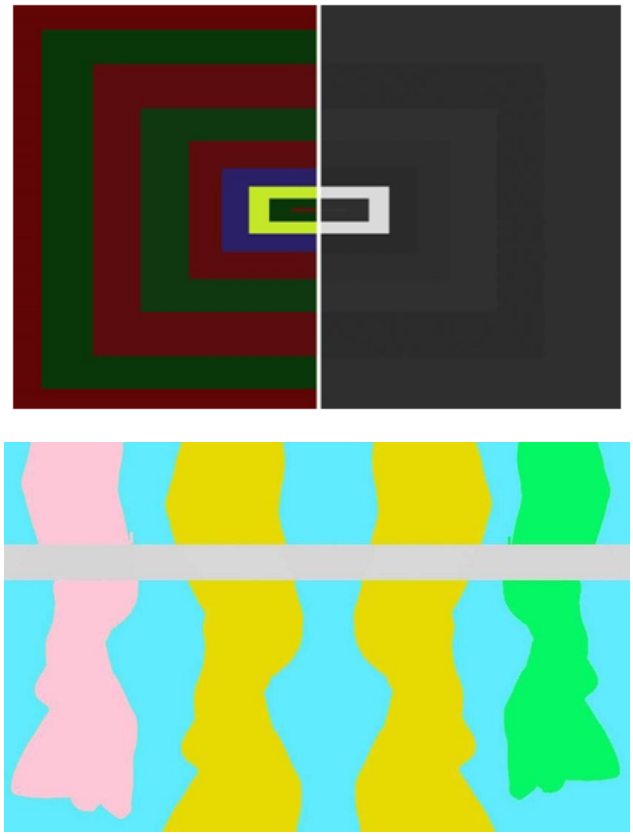

Figure 10: Illustration based on dark shades of red and green with a gray version, and a color illustration with the same gray key [16]

Figure 10 below shows a color illustration, which in the gray version turns into a single-color image (the horizontal strip of the image is converted to a gray color mode) [16]. This emphasizes the important role of color vision in human evolutionary life. By the way, the color of adjacent areas of the image is induced on this gray strip, although it is just gray (simultaneous effect) [17].

1.6 Perception and recognition of objects, spaces

The work [18] is devoted to methods for recognizing images and scenes with computer vision. Our visual system can recreate three-dimensional images based on a flat image. For computer vision, not only recognition algorithms are needed, it should also take into account lighting, shadows, the scene angle. Our knowledge of the world allows us to eliminate ambiguities. In the work for the recognition of scenes with computer vision, the use of gestalt rules for grouping objects is proposed [5], [19]. Images should be analyzed at the primary level from the whole to the particular, finding the connection and mutual influence of the components. Then, as a result of the analysis, information is determined and interpreted, then there is a classification and recognition of objects.

In [20], the influence of monocular vision on the accuracy of hand movement coordination during capture is described. It is known that when performing a movement, the eyes move before the movement. The movement of the eyes to the object analyzes and recognizes it in space, which facilitates the control of subsequent movements. However, monocular vision does not allow to fully determine the position of the object and hands in space. The experiment involved fifteen people who performed a control action using a video tracker and a motion capture system. As a result, the time interval of the process of taking the bead and putting it on the needle with monocular vision increased to 2.5 s, and with binocular vision it was 2 s. The results obtained confirm the decisive role of binocular vision in everyday life.

In [21], the influence of the significance of the content of the visual stimulus on eye movement is considered. The following visual stimuli were used: text, photographs of the urban landscape, landscapes, as well as their analogues processed stylized pseudo-stimuli. As a result, it was found that the duration of fixation and amplitude of saccades was longer for pseudo-stimuli, since their recognition and perception required more time.

In [22], the problem of creating a portable image recognition system for people with visual impairments is considered. Every day, these people are faced with issues of recognition and identification of visual information. A portable intelligent image recognition system based on cloud and local data processing technology is proposed (Fig. 11).

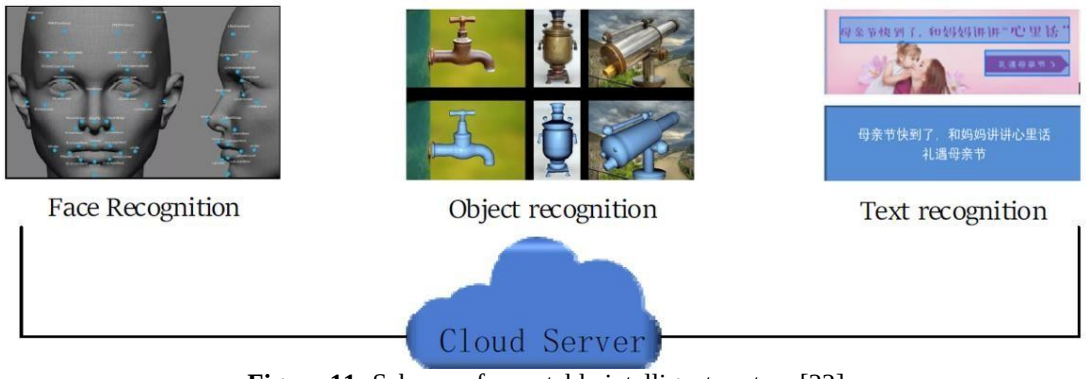

Figure 11: Scheme of a portable intelligent system [22]

The system is more economical because it uses high-performance algorithms of the cloud server, it captures objects, continuously scans the incoming video. The device was tested in real conditions by people with visual impairments, which made it easier for them to recognize faces, find the right people.

1.7 Visual Illusions

The review [23] is devoted to the study of visual perception illusions in schizophrenia. People with schizophrenia may experience abnormalities at various stages of processing visual information. Usually these people are immune to high- level illusions, and the impact of some primary stage illusions on them is also possible.

For example, consider the illusion of a “Hollow Mask” [24]. When viewing the mask rotates either clockwise or counterclockwise, successive steps are presented in Fig. 12. In fact, the mask rotates in one direction, but for most observers at some point the mask changes direction. At the beginning of rotation, the convex front side of the mask does not cause difficulties in the visual system, consciousness. When the mask begins to go to the wrong side (you can observe the background through the hollow eye sockets), our brain inverts it, we are more familiar with a convex mask. We are not used to seeing people with concave faces. With further rotation at the transition border, the brain once again inverts and returns the mask to its usual convex shape. However, the brain of a schizophrenic cannot be deceived, for him the mask remains after turning just a concave mask.

Figure 12: Sequential frames of the Hollow Mask illusion [24]

It should be noted that this visual illusion does not affect also some people in a state of alcohol and drug intoxication. Initially, this illusion was discovered with a hollow mask of the famous actor Charlie Chaplin. The distortion of reality and the processing of visual information refers to the properties of the brain of a healthy person. The study of the principles of the brain is a rather complicated area, even today there are no unambiguous explanations. What is more real? perception of a real picture of the world by the brain of a schizophrenic (without processing) or visual information processed by the brain of a healthy person?

2. Conclusion

This interdisciplinary review examined contemporary works in the field of perception and recognition of visual information, taking into account the artistic and compositional values of the analyzed scenes. The decomposition of the visual picture into structural components can be used in computer vision, analysis, recognition of works of art. The considered features of evaluating the field of view taking into account the movement of the eyes can be taken into account when developing intelligent systems to help the visually impaired. The combination of artistic features with modern recognition technologies can also be implemented in test systems for diagnosing the psychophysical state of a person.

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