METHOD FOR STUDYING THE DEPENDENCE OF THE VISIBILITY OF ARTIFACTS IN AN IMAGE ON ITS PHYSICAL DIMENSIONS

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An actual size of screen proposed displays video sequence influence the process of creating subjective quality evaluation of multimedia content perception on various devices. The question of display size and resolution impact on improvements in perceived visual quality still remains unclear. Any decisions on display size must demand understanding of physical, perceptual and cognitive opportunities of each user, also physical working/operational environment constrains. In proposed paper presented a method allowing to dynamically change the visual quality of a typical media content depending on the physical size of the display. The unique contribution of proposed study for the first time represents methodology of the degraded video images association with streaming video and their effects on various display sizes with fixed screen parameters. Method can be used for scientific purposes related to practical applications for visualization technologies, signal reception and processing in information technology devices, also in related areas such as marketing, advertising, film industry.

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I. INTRODUCTION

The question of video sequence perception by brain is the most important question of the research. The understanding of attention concentration, minimum video sequence quality acceptable for perception of content by human visual system, perception of color change and amount of color variations processes are important in modern systems of multimedia content perception. By understanding the processes, it is possible to figure out the sufficient level of visual data accuracy. Which in turn helps to decrease the cost of data storage, increase the bandwidth of video content per second and a great amount of other opportunities of resources, as the 82% of content on the Internet in 2022 is video content [1].

To better understand proposed process, an experiment was conducted in proposed research work, which is based on a subjective assessment of the quality of video sequences with distortions by a participant at different display sizes of video content. Proposed research will allow to understand the sufficient level of video content quality and a comfortable position relative to the screen diagonal for a typical user. Image size has a strong impact on the visual experience of watching TV and the quality of the resulting video content. the convenience of usage the screen of one or another size depends, first of all, on the distance from the viewer to the screen. The quality of the video sequences is determined by the video signal setting and screen resolution. The lower the resolution of a particular screen, the smaller its diagonal should be chosen. Pixel density is directly correlated with the quality of human video perception.

Proposed parameter, with a sufficiently high value, allows to look at the screen from a short distance and not endanger the human visual system (HVS), which is an urgent problem at the present stage of technology development, as an example, a monitor with a large screen in a relatively small room.

When choosing the optimal distance from the screen to a participant [2], three main factors are taken into account: the size of the screen, its resolution, and the field of view. All these three factors have a direct influence on each other. When the user gets closer to the screen, each individual pixel begins to appear larger. At close range, at close range image will look pixelated. But if the user is too far away, the screen display appears smaller, and the screen occupies a smaller user's field of view. The display size of the signal will also affect how much visual area the display devices should occupy in relation to the location of the user of the multimedia content. At best, there is a perfect balance when the user is at such a distance proposed the screen takes up the main part of the field of view, but not so close proposed the quality of the displayed information deteriorates. Getting closer the resolution will be greater than the comfort limit.

Angular resolution is the point at which the human eye can distinguish the individual details of the displayed information. The researchers suggest proposed a participant with 6/6 vision in the metric system (or 20/20 imperial) will be able to distinguish details proposed differ by 1/60 of a degree. The ability to distinguish details is determined not only by visual acuity, but also by the distance to the screen. At a certain distance, depending on the individual characteristics of the HVS the user will not be able to distinguish every detail [3]. The HVS will not be able to discern the display, if the user is too distanced, on the other hand, if the user is too close, proposed display will look pixelated. For lower resolutions, users need to be a little further than desirable to avoid noticing the pixels.

The main purpose of the study is to create a methodology proposed will answer the question: how the physical size of the signal display device affects the quality of video sequences at the present stage of development of multimedia content presentation technologies through subjective analysis of video content by users.

II. HYSIOLOGY SPECIFICITIES OF THE HUMAN VISUAL SYSTEM

In this paper presented 29 video databases with the subjectively rated for quality, following previous research [5], proposed in 2012 provided a comprehensive analysis of the video datasets at the time. The first studies regarding the human brain and information perception were focused on creating an analogue of the HVS with proposed technology. The concept of the process of the brain is the main task, the solution of which will allow modern society to improve the quality of life and save resources. With the improvement of technology, the analogues of the HVS were also improved. In the 21st century, neural networks are used for such studies.

David Hubel [4] in his works on the physiology of vision established proposed the path from the retina to the primary visual cortex has a topographic organization. The order in which the optic nerve fibers exit the retina is also preserved in the cerebral cortex. R. TooTell [5] was able to visualize proposed statement; experiments were based on the reactions of animals, namely monkeys. Humans have clear vision only in the central part of the retina, which is called the Fovea [6]. When human look at the world around us, our attention is almost always in proposed small point with an angular resolution of about 1 degree. It is impossible to expand the area of attention of the primary vision - it is the peculiarities of the physiology of the HVS.

Early vision refers to stages of proposed vision involve the capture, preprocessing, and encoding of visual information, but does not include the interpretation or other cognitive processing of visual information [7]. The process of perception of video sequences can be divided into three segments: filtering, encoding and interpretation. Where filtering and coding are related to early vision, and interpretation to cognitive processes

The viewer's ability to allocate cognitive resources to process mediated messages is always limited. When the means of providing information is a video sequence displayed on a screen, the rate at which new information is introduced is usually not controlled by the viewer, so most of the available resources are devoted to storing information to keep up with the flow of content and significantly reduce cognitive processing of the details of the transmitted information. The research with a focus on evaluating the quality of video sequences comparable to the perception of users should begin with the study of early vision and minimally taking into account the cognitive component. For proposed, it is necessary to use calm content for video sequences in testing on typical TV size.

III. M DOLOGY OF CREATING THE EVALUATION OF THE QUALITY OF VIDEO SEQUENCES FROM THE ACTUAL SIZE OF THE STIMULUS DISPLAY

The experiment is carried out in a special room where there are no light sources other than a projector. Before the test, the supervisor measures the brightness and fixes it (162 lux) using a polarizing filter mounted on the projector lens.

The variable density neutral light filter is made of two polarizing filters (two thin sheets of iodine crystal on a thin polyvinyl alcohol substrate) from a conventional LCD monitor, which allows to variably adjust the brightness. During the experiment, only 1 participant and 1 researcher are present in the room. The participant is shown a pre-processed video sequence in several instances, each instance has a different bitrate. Initially, video perception starts at the worst bitrate.

The participant has a manipulator for assessing the quality of perception of video content, which serves as a manipulator for improving the bitrate. When projecting a video, the participant must observe the absence of distortions / artifacts of the video sequence on the screen at his own discretion. 1 projector and 5 different distances were used in order to achieve the most identical image, because when changing monitors, not distances, the characteristics of each of the monitors could differ; beyond proposed, it is financially impractical, Table 1.

Data collection occurs automatically by logging readings to a file. The block diagram of the input signal processing algorithm is shown in Figure 1.

Table 1

Size of distances and physical dimensions of the screen

№ Pos.	Viewing Angle (degrees)	Distance from the screen to the point of the experiment (cm)	Screen diagonal (cm)
1	31	203	50
2	31	233	60
3	31	263	65
4	31	293	70
5	31	323	80

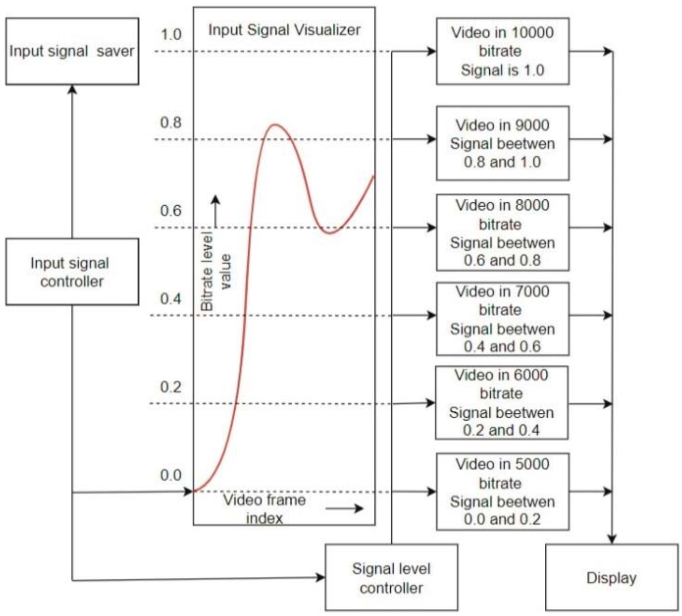

Figure 1. Block diagram of the input signal processing algorithm

Participants of the experiment aged 20 to 40 with normal vision. In proposed paper, normal vision is defined by typical user-generated content (in the Russian Federation, students aged 16 are required to undergo a general medical examination, including an eye test) [8, 9]. Participants do not use glasses, lenses, or other medical devices to correct vision in their normal daily activities.

Most of the participants should be inexperienced with the human perception of visual information. It is necessary to strike a balance between three important parameters: the physical maturity of the eyes, the daily use of typical user content, namely the viewing of videos and images on the Internet, and the lack of experience with the work of visual perception of information. Of these three parameters, the absence of visual perception experience is especially important, since the presence of such experience leads to improved detection of artifacts and detection of the perception threshold [8, 9].

Informed consent is obtained from all participants. After taking readings of the first position, the projector location is changed, and the participant remains in the same place. Then the procedure is repeated several times. To determine the positions of the projector, was used the study [8, 9], which says that the proposed maximum angular resolution of the human eye is 1 arc minute. From [10] it is possible to calculate the minimum and maximum allowable distance from the projector at which the stimulus is in the zone of clear vision [11, 12], Figure 2.

The scheme of the structure of the installation is shown in Figure 3. When the projector moves, the image changes not only in size, but also in brightness. To reduce proposed effect, a linear polarizing filter was attached to the lens.

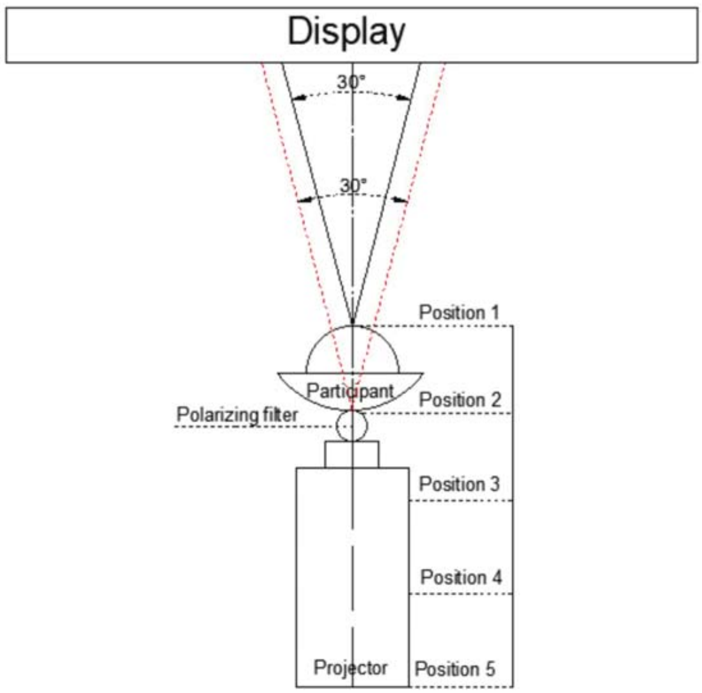

Figure 2. Scheme structure of the installation

If it is necessary to change the level of illumination, one of the films can change its angle to the other one, from an open state to a state of complete blocking of the passage of a light wave. When the position of the projector was changed, the surface of the screen was measured with a luxmeter, and the filter was adjusted to the illumination value adopted in the experiment. Description of installation:

1. Screen – used to display and evaluate streaming video data by the experiment participant. Specifications: The screen is a 22-inch 1080p monitor with a 16:9 aspect ratio, perpendicular to the viewing axis.

2. Projector – a stationary projector Christie DHD800, used to project onto a large screen information coming from an external source (in our case, from a computer), Table 2.

Table 2

Projector Specifications

Technology	DLP
Projector resolution	1920x1080 (Full HD)
Image aspect ratio	16:9
DMD panels	1
Manufacturer	Christie
Lamp Type	UHP
Lamp life	2000 h.
Number of lamps	2
Lamp power	330 Watt
Min. horizontal scan frequency	15 kHz
Pixel clock	Analog 230 MHz / digital 160 MHz
Min. frequency of vertical sweep	48 kHz
Contrast ratio	7500:1
Light output	8000 lm
The type of correction is ladder. distortion	vertical/horizontal
Connectors and interfaces	VGA input, HDMI input, RGB input, S-Video input, Composite and component video outputs, Ethernet, USB, Type-B, RS-232.
Noise level	38 dB
Width	400 mm
Height	242 mm
Depth	523 mm
Weight	19.7 kg

3. Participant of the experiment - the selection was carried out among 1st year students of the Moscow Technical University of Communications and Informatics. Students with normal vision (not wearing glasses/lenses) were selected. The method and rules of the experiment were immediately announced to the participants in order to avoid failures of the experiment.

4. Computer – a computer was selected in to be able to play 8 video sequences simultaneously.

5. Pedal – the manipulator for finding the minimum acceptable video quality threshold for one video. Proposed manipulator was made from the electronic gas pedal of a Lada Priora car, which has satisfactory ergonomics. It is assumed proposed the participant of the experiment will press or release the pedal to adjust the quality of the video with different strengths. To avoid ragged quality change with a limited number of levels, setting intermediate quality values using the pedal ensures proposed adjacent levels are synthesized in a proportion determined by the amount of pressure, Figure 3.

6. Lens with polarizing filter - Standard Zoom Lens: 138.4 – 59.9 mm F2.0 – 2.7.

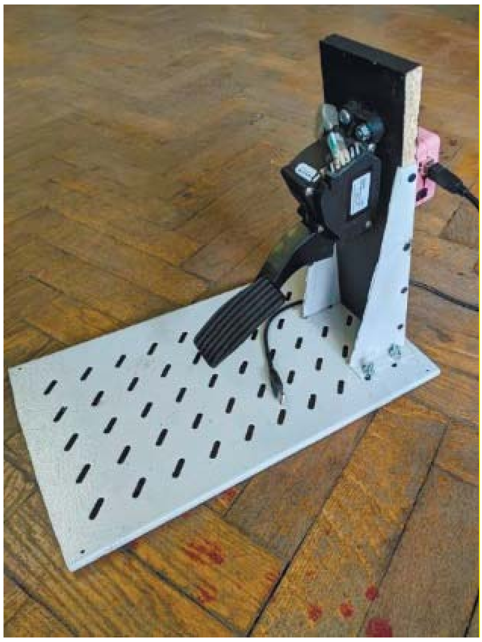

Figure 3. Manipulator [13]

IV. ANALYSIS

In order to obtain reliable data proposed will not have outliers, distortions and other deviant indicators, methods of mathematical statistics and big data processing were used. For these purposes, a program was written in the Python programming language, using third-party libraries such as NumPy, matplotlib and SciPy. The test experiment involved 5 participants tested in 5 positions.

Figures 4 show the results of processing the results for the positions of all participants. The data was frame-by-frame processed: each frame was examined for outliers, confidence intervals were obtained, as well as the average / center value of the frame.

Figure 5 shows the values of all experiments for 5 positions averaged between participants. The correlation coefficients for each data set and the mean were calculated.

Figure 6 shows the values of all experiments for 5, averaged over 100 times.

Was been comparing the results of the dependence of the perceived quality of video content on the distance to the display of the signal, as can be seen from Figures 10 and 11, there are clear differences in the perception of HVS of artifacts from the distance. The proposed principle of creating data for the perception of video sequences consistent with the distances to the signal display is preferable for implementation since it is the optimal compromise between computing resources and subjective tests.

The developed method for measuring the characteristics of the HVS allows to carry out previously unexisting complex studies with new approaches to obtaining data on the dependence of the perceived quality of video content on the distance to the signal display. In other words, it is now possible to obtain new measurements of the characteristics of the transmission of visual information by the human eye.

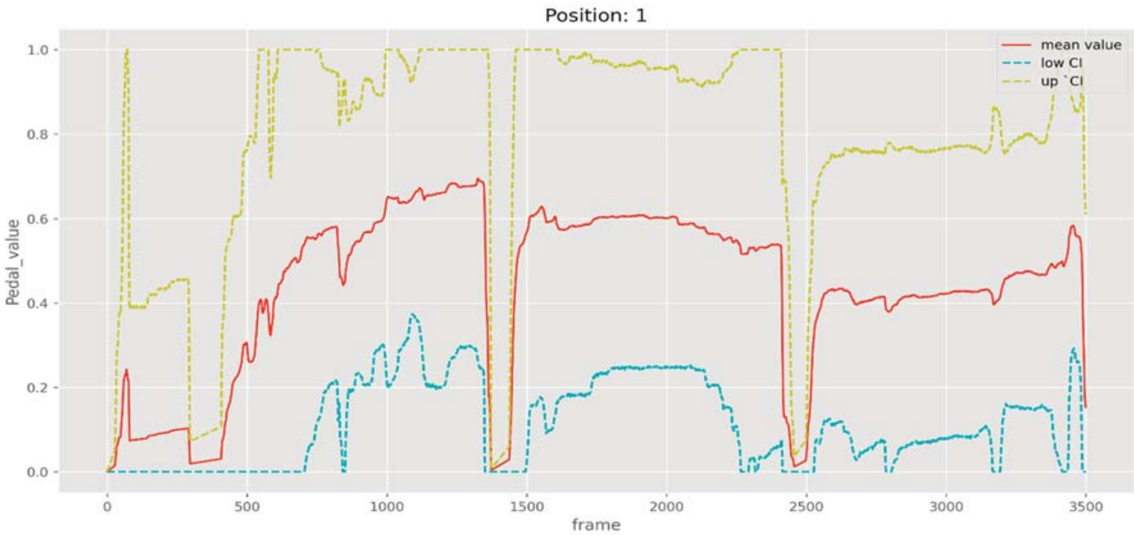

Figure 4. First position with confidence interval averaged between participants

Figure 5. Second position with confidence interval averaged between participants

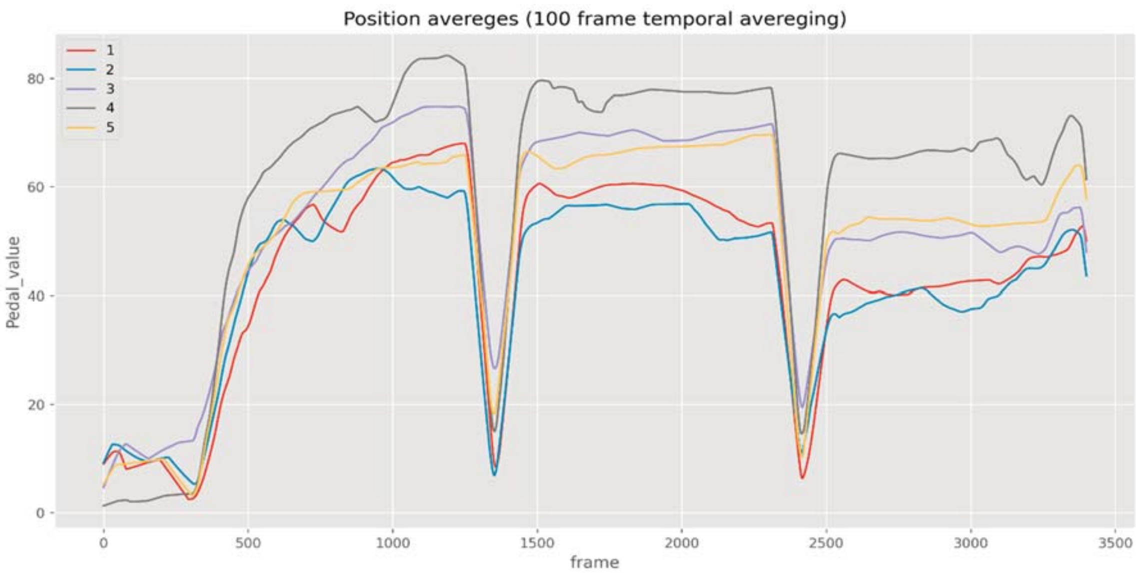

Figure 6. Five positions with average between participants and temporal averaging 100 frames

It should be noted that proposed work is not aimed at presenting complete experimental data according to the developed methodology. In proposed paper, a methodology for creating an assessment of the quality of video sequences from the physical size of the signal display is presented and a test experiment with 5 participants is carried out. Noting was proposed in order to provide results according to ITU-T Bt.500-11 [14], it is recommended to stop the subjective experiment when the confidence interval for the threshold measurement method between all participants is within 5%, therefore, to provide the results of experiments according to the developed methodology more participants are needed.

In addition to the main aim, the goal was to control all possible factors, the concentration of the participant in the experiment, the illumination in the room, the brightness of the image, the manipulator, and the viewing angle, leaving unchanged and the same for each participant passing the test. The only change was the screen size by increasing the distance from the monitor to the participant. Using proposed method, it can be possible to achieve a reduction in the probability of distorting the results by reason of different characteristics of the screens if they changed, and not the distance.

The purpose of the study was to analyze the effect of the actual size of the screen on the formation of a subjective assessment of the quality of the user experience by finding an acceptable minimum user experience threshold. In future work, in a large-scale experiment which will be using a sample of more than 10,000 stimulus perception thresholds, will be found controllable factors influencing the formation of a subjective assessment of the quality of perception dependence of display's size.

VII. CONCLUSION

The presented results describe the interaction between video impairments associated with video streaming and their effects on various physical display sizes with fixed screens. The present work has potential practical applications to supplement visual quality assessments based on psychophysical vision models. These models can well explain image and video quality, often outperforming metrics based on manual functions, statistics, or machine learning.

Our future work will include conducting a complete study. The new measurement methodology can be used for scientific purposes regarding practical applications for visualization, signal acquisition and processing technologies in information technology devices. Also, proposed method can be used for scientific and educational purposes related to the human visual system.

Presented methodology will improve the capitalization of advertising campaigns, streaming services, analysis of the target audience to interact with it, predicting the response of a participant when viewing content on any screen.

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МЕТОД ИССЛЕДОВАНИЯ ЗАВИСИМОСТИ ЗАМЕТНОСТИ АРТЕФАКТОВ НА ИЗОБРАЖЕНИИ ОТ ЕГО ФИЗИЧЕСКИХ РАЗМЕРОВ

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Аннотация
Фактический размер экрана, на котором отображается видеоряд, влияет на процесс формирования субъективной оценки качества восприятия мультимедийного контента на различных устройствах. Вопрос о влиянии размера и разрешения дисплея на улучшение воспринимаемого визуального качества до сих пор остается неясным. Любые решения по размеру дисплея должны требовать понимания физических, перцептивных и когнитивных возможностей каждого пользователя, а также ограничений физической рабочей/операционной среды. В работе представлен метод, позволяющий динамически изменять визуальное качество типового медиаконтента в зависимости от физического размера дисплея. Уникальный вклад этого исследования заключается в том, что оно впервые представляет методологию ухудшенных видеоизображений, связанных с потоковым видео, и их влияние на различные физические размеры дисплеев с фиксированными параметрами экрана. Этот метод может быть использован в научных целях, связанных с практическим применением технологий визуализации, приема и обработки сигналов в устройствах информационных технологий, а также в смежных областях, таких как маркетинг, реклама, киноиндустрия.

Ключевые слова: *угол обзора, расстояние до экрана, приемлемое качество изображения, битрейт, искажения восприятия.*

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