The Unconscious Response of Multimedia Content Consumers to Emotionally Significant Visual Symbols: Experimental Study and Oculometry Dataset

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Abstract. The publication discusses the problem of forming a dataset that can be used as a training sample for a neural network classifier capable of detection of destructive multimedia content. Special attention is paid to the procedure of experimental research, detection of anomalies and obtaining categorical estimates. The obtained dataset includes various emotionally significant visual stimuli and oculometric data of the subjects and makes it possible to use quantitative and qualitative criteria for assigning visual content to one of the classes: «toxic», «indifferent», «sanogenic». The dataset is free for non-commercial use and is available to researchers at Kaggle.com

Keywords: Training Sample, Anomaly Detection, Neural Network Classifier, Destructive Multimedia Content.

1 Introduction

The modern information society is characterized by the intensification and increase in the variety of types of communication processes in the social environment, implemented by technical means and related, at times, to diametrically opposite types of interaction [1].

A separate class of informational influences is formed by destructive phenomena that occur when users of modern telecommunication systems interact with potentially harmful multimedia objects of various nature (text, graphics, sound, video), the main consumer of this kind of content is being modern youth whose main hobbies are computer games, communication on social networks, watching videos and movies from the Internet.

These threats lead to the need to provide a healthy information environment. At the same time the problem of ensuring the psychological protection of the population from psycho-traumatic information is an important component of national security. [2].

At the legislative level the protection of the psyche of users from potentially hazardous information is implemented through the adoption of various regulatory legal acts.

In particular the German «Act to regulate the dissemination of writings and media contents harmful to young persons», the US «Children's Online Privacy Protection Act», Canada's «National Strategy to Protect Children from Sexual Exploitation on the Internet» and the UK's Internet Child Protection Plan. In Russian legal practice of countering a new type of threats in the field of information and psychological security, there is a system of legislative acts, including the Doctrine of Information Security of the Russian Federation, a series of documents approved by the Security Council of the Russian Federation, as well as a number of Federal laws and the Strategy of Scientific and Technological Development of the Russian Federation. Another way to provide protection of users from potentially hazardous materials is the so-called public approaches, which are based on the activities of initiative groups, public organizations and foundations that monitor Internet resources in order to identify the facts of placement and distribution of potentially dangerous materials in the telecommunications space. Currently the most effective strategy is considered to be the voluntary certification of multimedia products (movies and computer games) by their manufacturers and distributors - USK, ESRB, PEGI, CERO and a number of others. The software and hardware methods for protecting users against malicious influences on the Internet includes: blocking of IP addresses at the provider level, implementing special filters for search engines, as well as using of Microsoft Windows and Kaspersky Internet Security parental control features. The main disadvantages of the listed approaches are the high inertia of the existing legal mechanisms, which leads to the impossibility of timely detection and blocking of potentially harmful multimedia objects [3].

A possible solvation for this situation could be the development of an intelligent system that, using preventive measures, blocks potentially harmful information, reduces the speed of its distribution in the Internet space, increases the effectiveness of recognition and neutralization of potentially harmful multimedia objects on the Internet, and, ultimately, provides a guaranteed informational and psychological security of a person. Thus, the problem of effective multimedia content classification becomes very relevant which makes it necessary to form a training set of information objects of «negative» (potentially harmful) and «positive» (neutral) class. In contrast to similar studies conducted earlier, the described approach is distinguished by a significant reduction in the subjective component of the classification process [4].

2 Survey Procedure

The examination of the subjects was carried out on the basis of informed voluntary consent. The survey involved Russian-speaking students of the humanitarian profile university, both sexes in the ratio: male – 20%, female – 80%; age: 22 ± 4 years. No subjects during the session had any complaints about health, well-being, or mood. The average time of personal examination was 7 ± 3 minutes. Before the test procedure, each subject was shown how to perform the task. The survey itself was carried out according to the following scenario.

A subject was placed in front of PC a monitor (aspect ratio 16: 9 with a diagonal of 20 inches). A bar of the Gaze Point H3 video oculograph was mounted under the monitor. The main window of the ColorTest specialized test software was displayed on the monitor. In accordance with the examination technique, at the beginning of the session, the video oculograph was calibrated, after which the background recording of events on the monitor and the subject's eye behavior was activated.

The following stimuli were sequentially displayed on the monitor: ten specially selected antonymous word pairs which semantics was well known to the Russian speakers (good – evil, joy – grief, good – bad, etc.); then a series of images selected from the Geneva affective picture database (GAPED). The selection and presentation of visual stimuli on the monitor during the examination was organized in such a way that at first the subjects were shown a sequence of less emotiogenic (according to the GAPED developers) images, then a sequence of images was demonstrated, designed to cause indignation, anger, aggression in their acceptor (animals suffering during vivisection and/or killed by hunters); then a series of images designed to evoke emotions of compassion, pity, fear was demonstrated (people suffering or killed in a violent way). The next series of images contained positive themes: smiling children, mountain peaks, gardens, landscapes, happy people, etc. At the end of this block, images were shown in which people came into contact with spiders and snakes. After this «calibration» stage of the survey, the actual research stage began. The subjects were shown images taken from the Internet. The themes of the images were different: social advertising (no vulgarity or spelling errors, no flashy colors and shapes); commercial ads (possible spelling errors, frivolous scenes etc.); photos of drug addicts, intravenous drug users, adolescents, and substance abusers. The experiment was designed to substantiate an objective criterion for classifying graphic content with initially unknown semantics and emotiogenicity into one of three classes: neutral, positive, negative.

The problem was solved as follows. When the subject (volunteer) perceived presented at the monitor antonymic word pairs with experimentally established normative color associations, then, according to the experimental conditions, he had to associate with each stimulus word two color evaluation marks (or one and the same, but twice), guided by their own «inner feeling», without the need for rational justification of the choice.

As a result, a data array of data was formed containing the numerical values of the color pair index (CPI) (empirically obtained values of possible 64 pairwise color combinations of color assessment marks from the ColorTest software for each stimulus).

Then the mean and standard deviation were calculated for every class of the stimuli. As a result, a verifiable CPI value was obtained for verbal stimuli with positive (CPI _ «+») and negative (CPI _ «-») semantics. These values were calculated both for each individual subject and for the whole sample.

The «latent time of color-verbal association» indicator was also calculated. When a person who received an instruction to react in a certain way within the framework of known variations, was presented with some content on the monitor, he or she decided with which color marks to associate it and then realized his or her decision with mouse clicks on the selected color marks. This process took certain time and characterized the subject's temporal profile (complex cognitive-visual response).

Throughout the test procedure, a video oculography of the subject was performed. The parameters of eye reactions (fixation points, duration of fixation on areas and objects presented on the monitor, amplitude and angle directions of saccades, etc.) were linked with other parameters of test tasks. Color-associative tasks were performed in a similar way upon presentation of graphic stimuli. It was discovered that at the stage of presentation of antonymic word pairs the dispersion of bio- and psychometric parameters characterizing the behavior of the subjects was minimal (which made it possible to determine, among other things, the degree of sincerity and diligence in performing tasks by the volunteers), while the dispersion of parameters upon presentation of graphically stimuli with controlled semantics, emotiogenicity and expression turned out to be significantly higher.

Nevertheless, at this stage information was collected on color preferences, the accompanying temporal indicators of the visual-motor response of choice and the parameters of the subject's video oculogram in connection with the presentation of static graphic stimuli with complex semantics and color range.

As a result of the above described stages of the session, a data array was formed, allowing to calculate with a relatively high accuracy the ranges of numerical values of IC, reaction time and oculographic parameters corresponding to verbal and graphic stimuli of the three classes mentioned above.

With these data, it became possible to classify a graphic, verbal, or complex verbal-graphic stimulus to a particular class by comparing the associated bio-psychometric parameters and the corresponding parameters obtained for stimuli with known semantics, emotiogenicity and expressiveness, which was the final the purpose of the experiment.

The acquisition and processing of experimental data in accordance with the presented methodology is carried out using specialized software, the general algorithm of which is shown in the Figure 1.

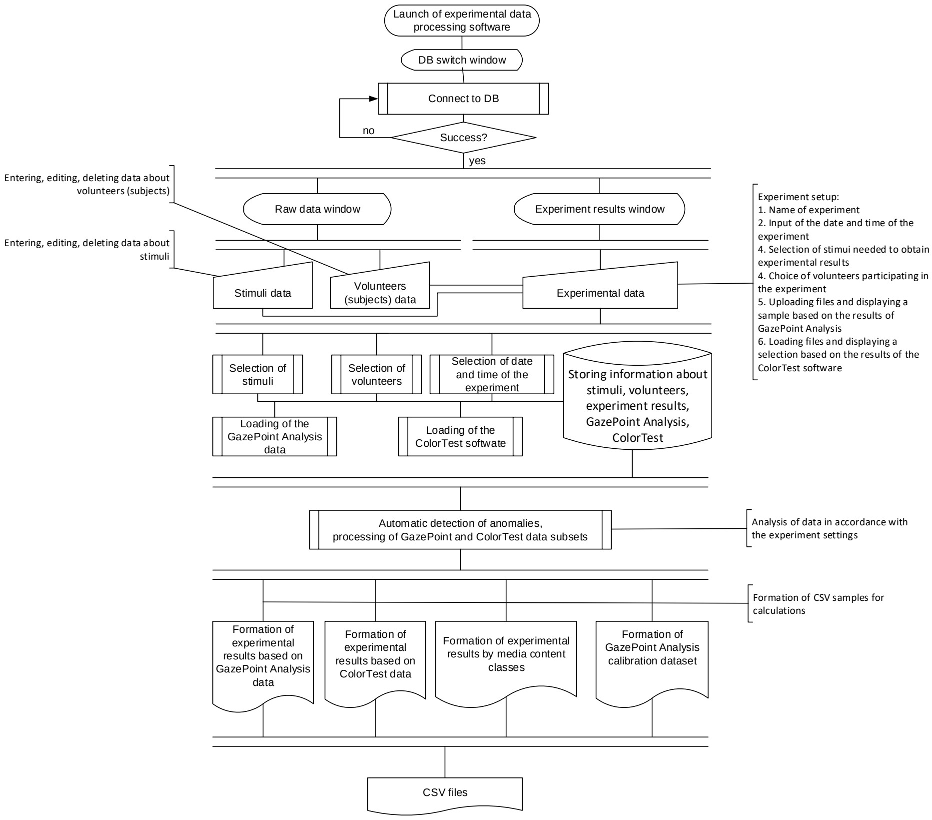

Fig. 1. Algorithm of the program for processing the experimental data.

3 Automatic detection of anomalies

An important stage in the preliminary processing of the obtained experimental data is the exclusion of anomalies (outliers). We consider two main sources of such anomalies. The first of them results from the laws of the theory of probability and is associated with possible presence among participants of the experiment persons whose emotional perception of the stimuli presented significantly differs from the perception of the rest of the subjects due to religious, cultural, intellectual and other characteristics. The second source of anomalies is of a psychological nature. In experimental studies conducted in the form of tests using questionnaires (in classical or electronic form – this does not change the essence of the experiment), when the subjects are forced to answer numerous questions with a limited number of answer alternatives, there is a risk of receiving questionnaires filled out randomly or according to some pattern (for example, all even answers are «yes», and all odd answers are «no»). These outliers can arise as a result of the subject's fatigue and the desire to complete the test as soon as possible, due to prank behavior, as a result of conscious opposition due to personal dislike of the experimenter, as well as a result of various combinations of these and other factors. The obtained outliers, regardless of the source of occurrence, can lead to a significant distortion of the estimates obtained on the basis of the collected data, and consequently, to erroneous conclusions when testing hypotheses, as well as to a deterioration in the quality of models built on the basis of available data using machine learning methods. Thus, the problem of automatic detection and elimination of anomalies is relevant for the research.

When detecting anomalies, the following difficulties can arise.

1) Determining the area covering all possible normal samples is difficult because the boundaries between normal and abnormal samples are often inaccurate, and an anomalous observation lying near the border may be normal and vice versa.

2) In the case of deliberate opposition, the subject can modify the data in such a way that the anomalous observations appear normal, making the classification task difficult.

3) The data may contain noise quite similar to actual anomalies and therefore difficult to distinguish from it.

5) The very concept of a «normal data» may have a vague nature. The current concept of a norm may cease to be such in the future, upon receipt of additional information about the object of research. With this regard, the solution of the problem of detecting anomalies in its most general form is difficult. Most effective modern methods of detecting anomalies solve this problem taking into account specific conditions, the nature of the data, the availability of a marked training sample, the type and nature of anomalies to be detected, etc. For classification methods based on supervised machine learning or statistical analysis, a prerequisite for their use is the presence of a labeled training sample. In this case, it becomes possible to train the model or calculate the distribution parameters for two classes of objects. In this case, methods such as random forest, logistic regression, SVM, etc. are applicable. However, in the case of our experiment, there is no reliable training sample and the dataset initially contains separate few anomalies that distort the statistical parameters of the distribution of the general population. In this case, it seems most appropriate to use a strategy based on the use of the isolation forest. The essence of the algorithm is that the anomaly can be isolated with fewer random splits compared to the «normal» sample, since outliers are rare and do not fit into the statistics of the dataset. The algorithm randomly selects a feature, and then randomly selects a value from the range of this feature as a separator. By recursively applying this splitting procedure, a tree is generated. The depth of the tree determines the number of random splits (isolation level) required to isolate the sample. The isolation level averaged over the forest of such random trees is a measure of normality and acts as a decisive rule for detecting outliers. Random splitting makes the trees significantly shorter for anomalous samples and longer for normal samples. Therefore, if a forest of random trees for a particular sample generates shorter paths, then this is most likely an anomaly. More formally, the algorithm can be represented in the following form: let the training set consists of N samples, the dimension of the feature space is M and m – number of features used for learning.

1. Generation of a random subsample (with repetitions) from a training sample of size N, in this case, on average, each sample will be included in the subsample $N \cdot \left(1 - \frac{1}{N}\right)^N$ times, and N/e samples will not be included in it at all.

2. Constructing a decision tree that classifies a given subsample: during the creation of the next node of the tree m features are randomly selected. To select the best feature, the Gini criterion or the criterion of information gain is used.

3. Classification of objects by voting: each tree of the committee assigns the object to one of the pre-defined classes, as a result the class for which the largest number of trees voted is revealed.

The optimal number of trees is determined by minimizing the classifier error on the test sample or by means of estimating the error of unselected elements. A measure of the normality of an object is the arithmetic mean of the depths of the leaves in which it fell. Thus, abnormal values fall into the leaves at a shallow depth of the tree. The advantage of this method is the possibility of high quality processing of both continuous and discrete data with a large number of features and classes, including missing feature values. The disadvantage is that required amount of memory for storing the model $O(K)$, where K is the number of trees. In the course of experimental studies for automatic detection of anomalies, an implementation of the isolation forest algorithm from the Scikit-learn library for the Python programming language was used with the following parameters:

- the number of trees – 100;
- the maximum number of counted features – 145 (according to the number of subjects);
- the proportion of results that can be attributed to abnormal – 7% of the total number of subjects.

Figure 2 shows a visualization of a random tree from an ensemble of an isolation forest, which highlights the test results of persons number 3 and 38 as potential anomalies.

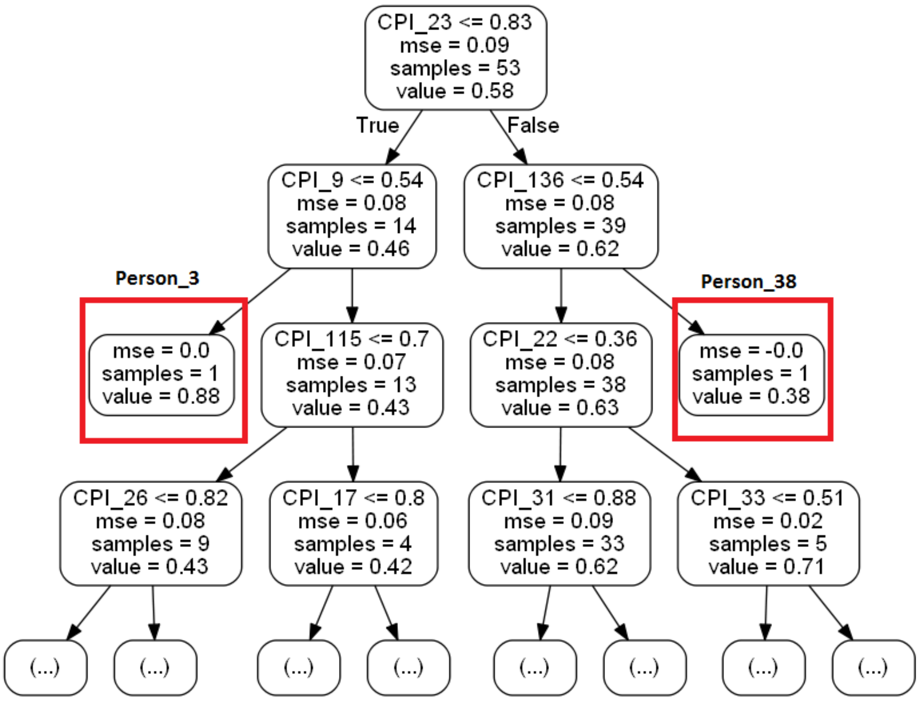

Fig. 2. Visualization of a decision tree from an ensemble of an isolation forest

The visual analysis of the results obtained can be carried out with the use of a dendrogram representing the hierarchical clustering of subjects (Figure 3) and a scatter plot in a reduced by means of principal components analysis three-dimensional space (Figure 4).

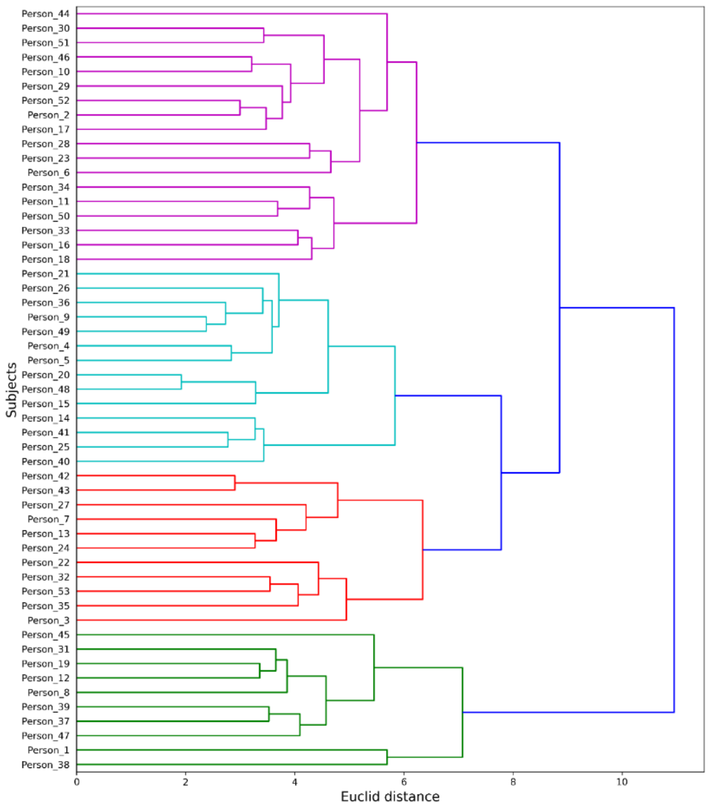

Fig. 3. Hierarchical clustering of 53 subjects in the feature space of 145 color pair indicies

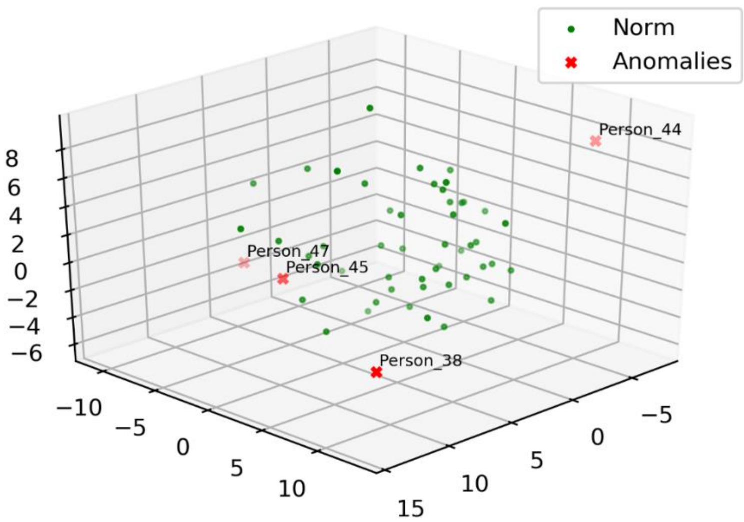

Fig. 4. Visualization of anomalies in three-dimensional feature space

The result of the described procedures is a list of subjects whose test results can be referred to as anomalies. In the case of our experimental study, those are the subjects with the identifiers Person_1, Person_38, Person_44, Person_45. Thus, as a result of the experiment carried out, a data set was formed that includes various emotionally significant visual stimuli and oculometric data of the subjects. The resulting data set is intended for processing by machine learning methods in order to obtain objective quantitative and qualitative criteria for assigning visual content to one of the classes: «toxic», «indifferent», «sanogenic». The dataset is free for non-commercial use and is available to researchers at Kaggle.com (https://www.kaggle.com/greeny598/oculometry-dataset).

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