Remote Usability Evaluation Using Eye Tracking Enhanced with Intelligent Data Analysis

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Abstract. In this paper we present a new cost-effective method for usability evaluation using eye tracking enhanced with intelligent data analysis. In this method we propose application of a low-cost infrared camera and free Ogama software. Moreover we present how the standard data analysis, which is usually made manually by experts, may be enhanced by application of intelligent data analysis. We applied well known expert system, which is using fuzzy reasoning. To build such a system we should first define a model of "desired" eye tracking record for a given poster, or more general web page or the whole application.

Keywords: Usability, Eye Tracking, Human Computer-Interaction, Fuzzy Expert Systems.

1 Introduction

In today's world we are surrounded by all sorts of advertisements. They are the fuel that runs the economy, so all advertising agencies are doing their best to come up with good designs for new posters, billboards etc. After such new designs are created they are usually evaluated by a group of people in a focus group research [1], [2], [3]. However application of a focus group evaluation is not perfect because in a real life customer usually has only a few seconds to recognize and memorize the product, for example when they are looking at a billboard while driving a car [1]. This means that focus group evaluation is only good for situations where customer has a lot of time to look at the advertisements. We can of course show our test participants the designs for a short amount of time and ask them what have they remembered, but this method does not give a good overview of the most visible and invisible parts of the design. Because of that more and more companies start to use a technique called eye tracking for this purpose [4], [5], and [6]. This method enables recording the line of gaze of user during the test, so it is possible to see where users were looking while they were evaluating the design. However the biggest drawback of the eye tracking technology is its cost. The application of the commercial eye trackers is too expensive especially in the developing countries, so smaller marketing agencies cannot cover these costs. We tried to perform such research using low-cost eye tracking method that we have implemented. For our study we wanted to show three different designs of the same

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product to the testers, just for a few seconds, to record, using eye tracking equipment, which parts of those designs testers were able to notice. Such case study would also show can our low-cost eye tracking method provide valuable results for visual media evaluation.

The construction of this paper is following. In the following section we present the tools we have applied in the usability evaluation, then we describe the experiment. In the section 4 we present the results of the eye tracking experiments. In the section 5 we describe the application of the fuzzy expert systems for the gaze tracking data analysis and finally in section 6 we present the summary and the future work.

2 Tools Used in the Experiment

Having a lot of experience with performing low-cost eye tracking using web cam [7], [8] we used the similar method with new applications. In this research we performed eye tracking with and infrared A4-TECH PK-333E camera[1], and ITU GazeTracker[2] combined with Ogama[3] software.

A4-TECH PK-333E camera is a very cheap camera, equipped with seven LEDs so it enables night vision. It has high image quality and works without delay at 640x480 pixels video resolution.

ITU GazeTracker [9], [10] is an open-source application that enables gazetracking using an infrared camera. It supports two methods of operating – pupil tracking and glint tracking. We need to obtain a clear image of the eye in order to perform effective eye tracking. Both methods use corneal reflection created by infrared light sources.

Ogama software allows recording and analyzing eye and mouse-tracking data from slideshow eye tracking experiments. Ogama is a freeware and open-source project. Its main features include database-driven pre-processing and filtering of gaze and mouse data, the creation of attention maps, areas of interest definition, saliency calculation and many more. Nearly any eye tracking and/or presentation soft- and hardware recordings in ASCII format can be imported. Direct recording is possible with commercial tracking such as Tobii and it also enables recording from open-source applications like the ITU GazeTracker.

To perform recording of the gaze or mouse data in Ogama we must create a slide show at first. It is done in the Slide Design Module. We can place different types of media on those slides such as images, text and flash animations.

After creating the slideshow we can proceed to the recording module in which we setup the participants' data. After that we can calibrate the camera with ITU GazeTracker and launch the slideshow and the application gathers the eye tracking data. After the test we can visualize these data. The visualization module can calculate Gaussian distributions of the fixation data and overlay it on the original stimulus image, so that we can see a landscape of seen and unseen locations on the stimulus. We can choose the subjects to include in the calculation and whether the calculation

[1] www.a4tech.com/product.asp?cid=77&scid=160&id=593
[2] http://www.gazegroup.org/
[3] http://www.ogama.net/

should be based only on the first or all fixations. Moreover Ogama allows to create Areas of Interest. Using this feature we can draw shapes on our slides and create areas that are most important to us. Using this option we can see the number of fixations and their total duration time, for one or many participants, in the given area of the poster.

The last tool that we used was Precision_test. We used this application to compare the precision of our eyetracking solution with the previous methods and a commercial ASL eye tracker [7].

3 The Eye Tracking Experiment

At first we needed to get several different designs for the same product. We decided to find some posters regarding social campaign instead of particular products, so we would not advertise any products. We decided to go with three posters of Polish "Speed kills" campaign – "Prędkość zabija"[4]. They all have the same structure. The main element is a picture of a particular situation. On the right site we have a slogan regarding the situation in the picture with reference to fast driving. At the bottom of each poster there is the main slogan and information about the campaign. All designs are showed in figure 1.

Fig. 1. Poster designs

4 www.predkosczabija.pl

The first poster shows a lady which is in a hurry and the slogan says “Sometimes you race against time?”. Second design is a man holding a young girl, probably his daughter, while going on a roundabout. The slogan says “Do you like spinning fast?”. The third design shows a couple lying in the bed and the slogan which may be translated as “Are you Speedy Gonzales?”

The second step was to determine the areas in which we would expect the participants’ gaze to spend the most time. Poster designers want to achieve specific goals by the means of visual patterns. The way in which viewers perceive posters, read and think about them depends on many factors. There are several general psychological rules of visual perception and many studies about text, web pages and digital banners contents visibility such as[11], [12], [13] were done. The usage of eyetracking in advertisements industry is well known [14], for example there is the rule of F-shaped pattern of gaze lanes made by web pages viewers [15]. In our experiment designers expectations about message transferred by a poster are more important than general principles. We have taken this presumption, as in the case of posters, it is important to convey specific information, in expected way. This is the basis for determining the real usefulness of the poster in achieving the assumed information functions.

Based on campaign materials we have elaborated sets of data, for each poster, including messages that they want to pass, so we were able to define essential areas, connected with corresponding message, that apply for all examined posters. General structure of examined posters is as shown in figure 2, where 1 - area showing people in strange situations, 2- short text area, 3 - slogan to remember, 4 - contact and reference for details.

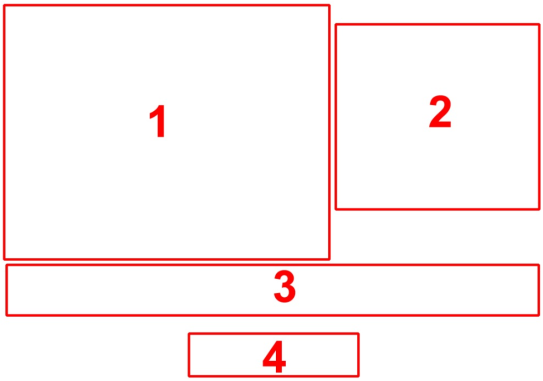

Fig. 2. Essential areas of interest for our posters

For this experiment we have taken a group of 20 people. The group consisted of 10 male and 10 female participants. They were all in a group age from 20 to 28 years old. Young people were the target group for this campaign because they cause the accidents according to the authors of “Prędkość zabija” (“Speed kills”) campaign.

For the first part of the research we have taken all the participants individually in front of a computer and set them up with our eyetracking gear. After calibrating the ITU GazeTracker application we ran the precision_test application and we have recorded the results of it. Because of the rather poor optics in our camera we needed to move it very close to the eye of the participant so we used a tripod. First thing that we have noticed was that the correct set up of the elements of the eye was very easy and very fast. ITU GazeTracker was automatically finding the pupil with just a few adjustments to the light and other parameters. We did not need to repeat the calibration process for the most of the participants because after the correct eye set up, the calibration had very good results most of the time. After that we have shown the participants each of the designs (in random order for each participant) for 4 seconds using Ogama software, and asked them to browse it as they would normally do with an advertisement. It is a time that user has to recognize and memorize the advertisement message that is placed on a billboard, bus or another object which makes it impossible to look at this ad for a longer time. During this test we recorded the eye tracking data for each participant in Ogama software. The whole process of performing such tests in Ogama was very easy and intuitive and we managed to complete the whole experiment without any problems.

4 Results of the Eye Tracking Experiment and Their analysis

At first we present the results from eye tracking study. We obtained three heat maps for each participant. We combined all those heat maps into one to show overall heat map for each design for all participants. Those maps are shown in figure 3. The "warmer" the color the more time users gaze spend in the particular area. The Gaussian kernel size was set to 333 for best visibility of the results.

Fig. 3. Eye tracking heat maps for each design

In a short interview after the test each participant said that the red slogan is visible, but the lower part of the poster with a body bag and white slogan is not visible at all and the main slogan "Speed kills" should be at the top of the poster, maybe also in red color. Furthermore participants suggested that the picture should represent an accident or something more drastic to have an impact on people.

As for the precision test, the average precision for all participants was 81,25 pixels. Precision_test, which we have conducted in our previous research, on ASL Eyetracker and Logitech Quick Pro Webcam combined with Opengazer[5] gave average precision 47,65 pixels and 122,67 pixels accordingly [7]. Moreover calibration process using ITU GazeTracker was a lot easier and faster than while using both previously used eyetracking solutions.

Using Ogama software we were also able to determine the number of fixations and the total fixation time for our areas of interest, as shown on figure 4.

Fig. 4. Total fixation time for every participant in every area for the third design

First of all we will look at the generated heat maps. For picture 1 it is clearly visible that the good looking woman has overshadowed the slogans, so with such design it would be hard to get the overall idea what this poster represents in just a few seconds. The second heatmap shows that the main points of focus were the faces, but participants also noticed the red slogan and the white sign, so they had some idea what this poster represents. The third heatmap shows that participants looked at the man for the most time, and they also noticed the lady, red slogan and the white sign along with the zipper.

Those heatmaps show that the lower parts of the pictures were not visible to the participants. The most important slogans and web address were completely invisible.

First design was interesting for male participants because of the good looking woman. However this was in overall the worst design mainly because of the situation, which did not suggest that this is a poster for anti fast driving campaign. Participants also pointed out the bad coloring and the fact that the woman in the picture draws too much attention.

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[5] http://www.inference.phy.cam.ac.uk/opengazer/

Second design was the most popular mainly because of the dynamics showed on this picture and also because it contained a scared child. Participants also liked the idea of the presented situation and the expressions on the faces of the father and daughter. The visual value of the picture was also the best in this poster.

The views on the third design were divided. Some participants insisted that the sexual subtext is a good thing that brings more attention to this design, while others insisted that this is a bit too vulgar and does not fit this campaign.

Generally all posters were rated poorly by the participants. First one and the third one should be used for advertisements of some other products and not for anti fast driving campaign. Second design was closest to what people expected, some dynamic and extreme situations showing the dangers of fast driving.

5 Applying the Intelligent Data Analysis

In our experiments only 20 participants took part, however for more reliable research also more participants is needed. But as a consequence we obtain more data for analysis, which in turn may be quite difficult. We propose to apply well known fuzzy inference systems [16] in usability verification based on gaze tracking data. Fuzzy inference systems are application of fuzzy logic and fuzzy set theory proposed by Lofti Zadeh in 1965. They are used to carry out very different tasks such as classification, diagnosis, process control or decision support, however they were also successfully applied in recommender systems [17].

The Mumdani model Of Fuzzy Rule Based System (FRBS) a is shown in Fig. 5, in this model the particular input characteristics is first mapped to the input membership functions (fuzzification), which then is mapped to rules that are mapped into a set of output characteristics and consequently to output membership function, which finally is mapped to a single-valued output associated with the decision (defuzzification).

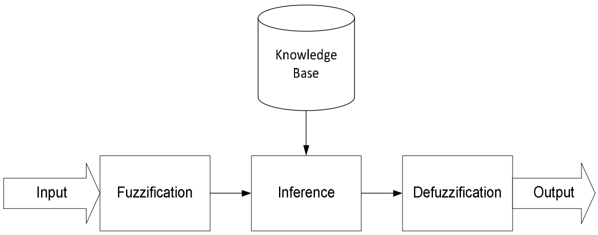

Fig. 5. Mamdani model of FRBS [18]

In our case we can select the following attributes concerning both the experiment participants' description such as: age, gender, education, place of living. The values of these attributes were used as the input to determine the membership function values of linguistic variables [16]. All the membership functions applied in the system have the trapezoid shape. The membership function values are defined as follows:

$$\mu_{trapezoid}(x) = \begin{cases} 1 & , x \in [b_1, b_2] \\ \dfrac{x - a_1}{b_1 - a_1} & , x \in [a_1, b_1) \\ \dfrac{a_2 - x}{a_2 - b_2} & , x \in (b_a, a_2) \\ 0 & , otherwise \end{cases} \quad (1)$$

For example for variable *x* representing the participants' gaze time (in seconds) being short, we have the following values of a_1=2, b_1=4, b_2=6, a_2=8.

The attributes were used to construct fuzzy inference rules that for some assumptions expressed in so called linguistic values (eg. short time) assign conclusions concerning usability also expressed in the linguistic values. Depending on the complexity of the poster (number of the different regions) and the differences among the participants the system the number of the inference rules may vary from about 20 to over 60 in the following form:

If the age of the participant is medium and the gaze time at region 1 is long and the gaze time at the region 4 is short then the usability of the design is high.

Each rule has associated confidence factor ($cf \in [0,1]$) given by the expert, which expresses his or her confidence in the particular rule. The *cf* multiplies the membership function value of the outcome of the rule and by default this factor is set to 1.0.

The defuzzification process is based on a very simple method called Mean of Maximum (MOM) [16], which takes the mean value of the set with maximum membership grade. According to the fuzzy inference system we determine values that represent the usability of the particular design, for the particular experiment participant, particular group of participants, the all the participants or select the best design according to the highest usability value.

6 Summary and Future Work

In our experiment we have shown that this low-cost eye tracking method can be used to perform a professional visual media evaluation and can be an additional tool to standard techniques such as focus group research. ITU GazeTracker combined with infrared camera provides descent eye tracking precision in comparison to commercial ASL eyetracker. Furthermore this method provides better precision than previous methods that we have developed earlier and presented in works [7] and [8]. Also the setting up and the calibration process are easier and faster with this method comparing with the previous one. As for the Ogama software it provides a very efficient testing environment for eye tracking. It is easy to set up a slideshow and the camera with eye tracking. Generated heatmaps look very professionally and an option for generating heatmap based on the data from many participants is a very useful addition. The data gained from the areas of interest allowed us to perform the second part of our analysis

– intelligent analysis of the eye tracking data. Using eye tracking allowed us to precisely determine which areas of the design were visible and which were invisible to the participants in the first four seconds of their encounter with given media. It was a simulation of a real life situation in which recipients view a poster or a billboard just for a few seconds, and its design should give all the necessary information in this short time. Eye tracking allows evaluating any visual media this way. It gives more empirical information about the design than the discussion with participants of the focus group.

We have also presented how we can enhance the process of gaze tracking data analysis by application of fuzzy reasoning. The most important advantage of this method (besides low cost of eye tracking device) is that it may be used to analyze the data gathered for single user, several users or even hundreds of users, which will give the statistical significance. However one of the drawbacks of this method is necessity of definition or redefinition of set of rules for the different experiments. This problem may be solved by application of determining fuzzy rules out of experimental data [19].

This method that we presented can be used not only in evaluating posters, but also in many other types of media and also in website usability testing. Its precision was not as good as the precision of a commercial eyetracker, but for smaller companies it is a very good alternative for such tests.

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