Synthesis
International Scientific Conference of IT and Business-Related Research

EVALUATION OF THE APPEAL OF WEBSITE DESIGN TO A TARGET GROUP WITH THE AID OF ARTIFICIAL NEURAL NETWORK SOFTWARE

PROCENA DOPADLJIVOSTI DIZAJNA I RASPOREDA ELEMENATA VEB SAJTA PRIPADNICIMA CILJNE GRUPE KORIŠĆENJEM VEŠTAČKIH NEURONSKIH MREŽA

Milan Tair, Marko Petrović
Singidunum University, 32 Danijelova St., Belgrade, Serbia

Abstract:
This paper presents the method of using an artificial neural network to evaluate the appeal of website design and layout to members of a target group, with the design being defined according to predefined parameters describing section properties. We have trained the neural network with a sampling set based on the survey participants' website design evaluations. For the purpose of project implementation, we have utilized an open source JavaScript library for neural network simulation and our own implementation of a dynamic website preview generator. The paper presents a derivative application that uses the trained neural network to generate suggested website designs and their feature parameters that are likely to be appealing to the members of the target group matching the survey participants.

Key words:
artificial neural network, website design, JavaScript, machine learning.

Apstrakt:
U radu je prikazan metod primene veštačke neuronske mreže u cilju ocene dopadljivosti dizajna i rasporeda elemenata veb-sajta pripadnicima ciljne grupe, pri čemu je dizajn definisan prema unapred utvrđenim parametrima koji opisuju osobine elemenata. Neuronsku mrežu smo trenirali pomoću skupa uzoraka ocena dopadljivosti veb sajtova, sakupljenih putem ankete. U implementaciji ovog projekta, koristili smo JavaScript biblioteku otvorenog koda za simulaciju neuronske mreže, uz sopstveno razvijen dinamički generator prikaza veb sajta. U radu je prikazana izvedena aplikacija koja koristi treniranu neuronsku mrežu za generisanje predloga dizajna veb sajtova sa parametrima koji određuju njihove osobine, a koji se dopadaju pripadnicima ciljne grupe koji odgovaraju učesnicima ankete.

Ključne reči:
veštačka neuronska mreža, dizajn veb-sajta, JavaScript, mašinsko učenje.

1. INTRODUCTION

Artificial neural networks (ANN) simulate the basic organizational features of the biological nervous system. Even though there are many definitions explaining what an ANN is, there is no single, generally accepted definition. The most commonly used definition is the one provided by the creator of the first commercial neurocomputer, Robert Hecht-Nielsen, Ph.D. This definition states that an ANN is a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs (Filo & Lotan, 2010).

In order to be accessible, website content must conform to certain accessibility principles. It is essential to plan all features needed for the website design, layout and content. Important steps in website design development include identifying the target audience and defining the purpose and structure of the content (Siddiqui, 2008). When testing possible website layouts, the developer creates and evaluates a mock-up model or a conceptual design of the website layout. A number of parameters that describe the most important aspects of the website layout and design can define the conceptual design. These include the total page width and screen occupancy, website background and text colour, brightness, element outlining style, illustration and image sizes, header and footer appearance (Sfetcu, 2014). There are different methods for evaluating conceptual design with the aim of identifying the optimal layout and design parameters for a model. Such methods include manual evaluation by experts, testing with users and automatic validation of accessibility outlines (Zaphiris & Kurniawan, 2006).

User testing is usually the preferred method of identifying the desired website layout and design for the target group. Surveyors select respondents from the target group. The issue with this method is that surveyors must select, organize and motivate a new group of respondents every time they assess a new conceptual design. After collecting test group participants' inputs, data must be statistically analysed, filtered, sorted and results reviewed for errors (Hayes, 2008).

Our paper attempts to utilize an ANN in order to make the user testing method of design evaluation for a certain target group available multiple times instead of only once for a certain design model. With this approach, we have aimed to eliminate the need for selecting and organizing a survey group for every new conceptual design evaluation.

This paper presents the application of an ANN in finding optimal parameters that define website layout, which appeals to the majority of the survey respondents. The survey respondent inputs include evaluations of randomly generated website layouts based on the predefined set of parameters. We have used these inputs to train the neural network. Each input includes a list of parameters used for dynamically generating a sample website design, the evaluation score given by the user and gender information. The implemented ANN model that is most widely used (Alias, George, & Francis, 2013) is multilayer feedforward ANN model with the error back-propagation training algorithm.

E-mail: milan.tair@gmail.com
DOI: 10.15308/Synthesis-2015-27-31

2. DATA COLLECTION METHOD

A diverse training set matching input values to output values is required in order to train a feed-forward ANN. The larger the training set, the longer it will take to train the neural network, but the resulting neural network would make fewer classification errors (Filo & Lotan, 2010).

We have devised a method of collecting data from a group of users from our target group, which utilizes a dynamic website design and a layout generator written in JavaScript. Values of identified parameters that define website design and generate a minimized visual representation are the inputs of the generator. The survey uses the dynamic website design and layout generator to display sample website designs to survey participants. Random sets of values for input parameters define each website design sample. Survey participants evaluate the displayed website design by marking it as appealing or displeasing, according to their personal preferences. All survey submissions included the data on the participant's year of birth and gender. It was necessary for all the participants to submit a minimum of 30 website evaluation submissions. We have used the year of birth to calculate the participant's age in order to filter out surveys submitted by the participants outside our target group. The target group included male and female respondents aged between 18 and 35.

2.1. IDENTIFIED WEBSITE PARAMETERS

We have identified 12 technical parameters that can describe the technical modus for website layout design, each with a distinct set of possible values for each parameter. Identified parameters define a range of characteristics of website layout. These characteristics include the existence and positioning of blocks such as navigation, sidebars and sliders, background and text colouring, image sizes, blocks outline visibility *etc.*

The following list shows the identified parameters with their possible values:

1. The "Website wrapper width" parameter controls whether the website content should spread out to match the available window width or be contained inside a fixed width centred column. Possible values for this property are "full screen width" and "fixed width column".
2. The "Elements outlined with borders" parameter controls whether all block elements that make up the website page should have visible outlines or not. Possible values for this property are "borders invisible" and "borders visible".
3. The "Overall website colour brightness" parameter controls the website body and element background colours. Possible values for this property are "predominantly dark colours" and "predominantly light colours".
4. The "Overall website colour saturation" parameter controls whether images used in website page content should have bright or dim picture data. Possible values for this property are "predominantly unsaturated colours" and "predominantly saturated colours".
5. The "Website content text colour" parameter controls the website text colours. Possible values for this property are "bright text colour" and "dark text colour".
6. The "Website's main navigation bar orientation" parameter controls the orientation of the main navigation menu. Possible values for this property are "horizontal menu bar orientation" and "vertical menu bar orientation".
7. The "Image slider availability and size" parameter defines whether or not the website should have an image slider and whether the image slider should be small or large. Possible values for this property are "no image slider", "small image slider" and "large image slider".
8. The "Relative size of in-page images" parameter defines the relative size of the website page content images. Possible values for this property are "small images in page content", "medium size images in page content" and "large images in page content".
9. The "Number of columns for page content distribution" parameter defines whether the text content should span the full-page width in a single column or if split into multiple columns. Possible values for this property are "single column" and "multiple columns".
10. The "Sidebar availability and position" parameter controls the availability and the position of website sidebars for additional related content. Possible values for this property are "no sidebars", "left sidebar", "right sidebar" and "both left and right sidebar".
11. The "Website header availability" parameter controls whether or not the website should have a header section. Possible values for this property are "website has a header" and "website does not have a header".
12. The "Website footer availability" parameter controls whether or not the website should have a footer section. Possible values for this property are "website has a footer" and "website does not have a footer".

2.2. DYNAMIC WEBSITE PREVIEW GENERATOR

The dynamic website preview generator creates a minimized visual representation model with different layouts and website features, by adding and removing predefined cascading style sheets (CSS) to a predefined "Hypertext Markup Language" (HTML) mark-up structure. By dynamically applying or removing (Ferguson & Heilmann, 2013) CSS classes (Matthew, 2013) with JavaScript to different HTML elements within the sample website mark-up structure, those elements are hidden, resized, recoloured and repositioned within the visual representation of the sample website.

2.3. DESIGN AND LAYOUT EVALUATION SURVEY

In order to evaluate collection process, we have created a web-based survey system. The system integrates our dynamic website sample design and layout generator and a PHP script that connects to a MySQL database that stores user evaluation information. The developed survey system has two stages. In the first stage, the survey collects the information on the participant's gender and year of birth. The second stage collects evaluation marks given by the survey participant for website samples based on the sets of randomly generated parameters. The second stage includes a set of 30 mandatory samples for evaluation. After evaluating the mandatory set, the survey participant can continue evaluating new random generated samples.

Each evaluation stored into the database is time-stamped and contains the user identification number located in a small file that contains user session information, which is called a cookie, and is stored on the user's computer (Dark, 2010). The evaluation record includes the set of parameters for the evaluated website sample design and the user's evaluation mark.

DOI: 10.15308/Synthesis-2015-27-31

3. ARTIFICIAL NEURAL NETWORK TRAINING

The collected evaluation data contained 6295 samples assessed by 39 (51.32%) women and 37 (48.68%) men. The collected data comprised survey submissions from the respondents aged between 19 and 35 years. They have submitted a variable number of evaluation submissions per respondent, ranging from 30 to 424. All respondents were students or graduates from Bachelor or Master's degree programmes with residence in Belgrade, Serbia.

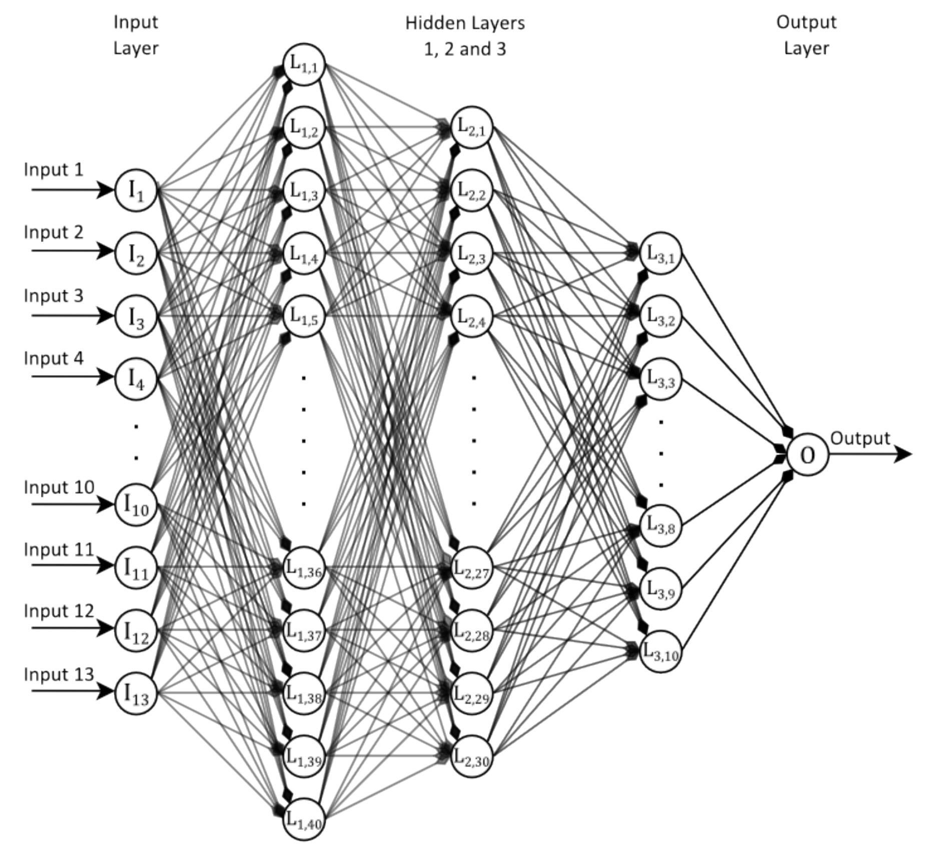

Figure 1. The diagram of the artificial neural network used in our work

The neural network simulation software used was a JavaScript library called Brain.JS[1], originally developed by Heather Arthur. The neural network was initialized as a multilayer ANN with a pre-set number of hidden layers and neurons per layer, likely sufficient to yield the targeted mean square error.

We have initialized the ANN with 13 neurons in the input layer and 1 neuron in the output layer. There are three hidden layers with 40, 30 and 10 neurons per layer, respectively. In Fig. 1, we show a diagram of the ANN trained with the collected training data.

The collected information was converted into a JSON formatted string as required by the Brain.JS library training function. The training process was initiated with the targeted mean square error of 0.1% and a learning rate of 0.1. The maximum number of iterations was set to 100,000. The learning rate is the measure of the speed of the network convergence. Smaller values of the learning rate will not correct the error quickly, while larger values might cause the learning algorithm to pass by the target value. This could cause the network to oscillate and never reach the targeted low mean square training error (Zhang, 2008).

1 Source code available at github.com/harthur/brain

4. RESULTS AND DISCUSSION

The ANN training algorithm completed the training process without reaching the targeted training error of 0.1% by reaching the value of 0.26% after training for 100,000 iterations. The training process took 519,654 seconds to complete.

The trained neural network evaluated website designs defined by all possible combinations of website design and layout parameters for both genders. The list included 36,864 combinations, each with 13 input values and 1 output value, ranging between 0 and 1. The outputs were the result of neural network activation. The neural network inputs were the 12 parameters and the gender value, taken from the combination list, one combination at a time.

The following table includes 10 combinations of inputs and outputs from both ends of the table sorted based on the output value in the descending order, with five combinations from both ends.

Values for the input parameters in Table 1 indicate the selected option in the order given in the parameter list shown in the Identified website parameters section of this paper.

Value 1 indicates that the corresponding parameter's value is the first suggested in the list and Value 2 that it is the second suggested, *etc.* The gender column contains values M and F, corresponding to the male and female gender of the survey participant, respectively.

The output value is a number ranging between zero and one. The value close to zero indicates that the matching combination of parameters is least likely to be appealing to the corresponding gender in the reviewed row. The value closer to one indicates that the matching combination of parameters is more likely to be appealing to the corresponding gender in the reviewed row.

For instance, according to Table 1, the evaluated combination shown in the first row translates to website design and layout illustrated in Fig. 2 most likely to be appealing to the target group members of the female gender.

The last row of Table 1 contains parameter values that translate to the preview of a website design and layout combination, which is least likely to be appealing to target group members of the female gender.

As can be seen in Fig. 3, the deficiency of a proper background-to-text contrast leads to poor readability, while the overwhelming use of outlines and disproportional sizes of page content images yield to the disseverance of focus from the content.

5. SUMMARY

We have surveyed 76 respondents and collected 6295 evaluations of random generated website design and layout previews. Twelve parameters, which we have identified as sufficient to create most layout and design features of classical web pages, de-

DOI: 10.15308/Synthesis-2015-27-31

Website wrapper width	Elements outlined with borders	Overall website colour brightness	Overall website colour saturation	Website content text colour	Navigation menu bar orientation	Image slider availability and size	Relative size of in-page images	Number of page content columns	Sidebar availability and position	Website header availability	Website footer availability	Survey participant's gender	Trained artificial neural network activation output value indicating the probability that this combination of inputs would be appealing to the target group member of the tested gender
2	1	2	2	2	2	3	1	1	1	2	2	F	0.9999921158817660000000000000000
1	2	1	2	1	2	3	2	2	3	2	2	M	0.9999920861108040000000000000000
2	1	2	2	2	2	2	2	1	2	2	1	F	0.9999919195696990000000000000000
2	2	1	2	2	1	3	1	1	3	1	2	F	0.9999918320938040000000000000000
2	1	2	2	2	1	2	2	1	4	1	1	F	0.9999917214578890000000000000000
1	1	2	2	2	1	3	2	1	4	2	2	M	0.0000000000000000000000000000455
1	1	1	2	1	2	3	1	2	3	2	2	M	0.0000000000000000000000000000435
2	2	2	2	2	2	3	2	2	3	2	1	M	0.0000000000000000000000000000102
2	2	2	2	1	1	3	3	1	4	2	1	F	0.0000000000000000000000000000101
2	2	2	2	1	1	2	3	1	4	2	1	F	0.0000000000000000000000000000082

Table 1. Sample combinations of inputs and ANN evaluated output values

Figure 2. The preview of a website design and layout defined by the combination most likely to be appealing to female target group members

Figure 3. The preview of a website design and layout defined by the combination the least likely to be appealing to target group members of female gender

fined website previews evaluated by the respondents. The survey included information on participant's gender and birth year. The information on birth year was used to calculate the participants' age in order to filter out surveys from the respondents outside the target group. The target group included male and female respondents aged between 18 and 35.

In this paper, we have presented an implementation of artificial neural network software, used to train a neural network to evaluate website design and layout previews. We have trained the neural network to take 13 inputs. There are 12 parameters among those inputs, which define the conceptual design and gender of the target group member. The neural network simulates the evaluation decision that the target group member of the selected gender would most likely make.

Based on the evaluation of the decisions made by the neural network for all 36,864 combinations of 12 input parameters and a gender parameter, we have assembled a table of evaluations. This table shows the probability for a combination of parameters to be appealing to a member of the target group of a certain gender. By assessing these results, we have identified the appropriate conceptual designs most likely to be appealing to the members of both genders of the target group, as well as conceptual designs that are least likely to be appealing to the members of both genders of the target group.

DOI: 10.15308/Synthesis-2015-27-31

REFERENCES

Alias, A.M., George, P., & Francis, A. (2013, December). Neural Network Based Temperature. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, II(1), 103-110.

Dark, M.J. (2010). Information Assurance and Security Ethics in Complex Systems: Interdisciplinary Perspectives (1st ed.). Hershey: Idea Group Publishing.

Ferguson, R., & Heilmann, C. (2013). Beginning JavaScript with DOM Scripting and Ajax: Second Editon (2nd ed.). New York City: Apress.

Filo, O., & Lotan, N. (2010). Information Processing by Biochemical Systems: Neural Network-Type Configurations. Haboken: John Wiley & Sons.

Hayes, B.E. (2008). Measuring Customer Satisfaction and Loyalty (3rd ed.). Milwaukee: ASQ Quality Press.

Matthew, D. (2013). HTML5: Designing Rich Internet Applications (2nd ed.). Abingdon: Taylor & Francis.

Sfetcu, N. (2014). Web Design & Development. Raleigh: Lulu Press Inc.

Siddiqui, M.H. (2008). Educational Technology. New Delhi: APH Publishing Corporation.

Zaphiris, P., & Kurniawan, S. (2006). Human Computer Interaction Research in Web Design and Evaluation. Hershey: Idea Group Inc. Global.

Zhang, M. (2008). Artificial Higher Order Neural Networks for Economics and Business. Hershey: Idea Group Publishing Global

DOI: 10.15308/Synthesis-2015-27-31