TRANSFER LEARNING BASED CLASSIFICATION OF SEGMENTED LANDING PAGE COMPONENTS

Ç. Şenel, G. Ayhan, Z.E. Uran, and B.U. Töreyin

Abstract**—** The pages that appear in front of users on digital platforms used for online advertising to attract attention to target product are called landing pages. Landing pages aim to increase advertisement conversion rate using the metrics like clicks, views or subscribes. In this study, a method is presented to automatically classifier the most commonly used components on landing pages which are buttons, texts, and checkboxes. Landing page images given as inputs are segmented by morphological and threshold-based image processing methods, and each segment is classified using a Transfer Learning based method which combines pre-trained Inception v-3 networks and Support Vector Classifier (SVM). Furthermore, different classifiers were applied to compare the results. The proposed method is anticipated to be an essential step in the process of designing landing pages automatically with high advertisement conversion rates. Thanks to the proposed transfer learning based method, this is achieved by using fewer number of training data.

Keywords**—***Landing Page Segmentation; Transfer Learning; Image Processing; Image Classification.*

1. INTRODUCTION

A LANDING page is a page specifically designed for a particular target audience or product, especially for being used in digital marketing activities. The purpose of these pages is to increase digital conversion rate by using metrics like clicks, views or subscriptions. Landing pages have designs that contain an aim and message intended for the target audience and affect the conversion rate. Landing pages that are inadequate in design and do not correspond the expectations of users lead to low conversion rates [1,16].
Designs of landing pages commonly consist of components such as buttons, checkboxes, texts, and pictures. A representative landing page with related components is shown in Figure 1.

To the best of our knowledge, there are a very limited number of studies to segment and classify the landing pages for online advertising [19]. However, there are many studies about image segmentation and classification in computer vision and image processing literature [2-4,6-11].

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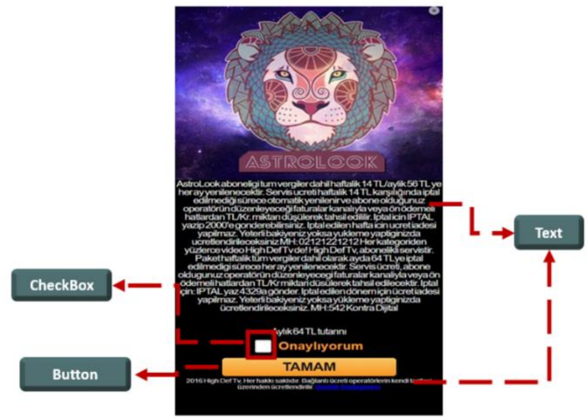

Fig.1. A representative landing page in online advertising and the most commonly used components of landing pages; "text," "checkboxes" and "buttons."

Among them, there exist studies on text detection in color images, as well [5-6]. Segmentation methods divide the image into components by using properties, such as, pixel density, color, texture, etc., [9]. The methods used for successful segmentation of the images differ [10]. Multiple image segmentation methods can be combined considering the ambiguity and variety of images [11].

Deep learning algorithms, especially Convolutional Neural Networks (CNN), have been widely used to classify images [23-25]. Even though CNN has acquired remarkable achievement in image classification [12-14], there have been some cases that image classification through CNN was not the proper approach. In particular, there may arise overfitting and convergence related issues when dataset sizes are too small to train a CNN model [26]. Due to increase in the performance of CNNs with massive datasets, network sizes have been increased in many studies with complex architectures [27]. However, the complexity of model may lead overfitting [18]. Consequently, domain adaptation and transfer learning based approaches may be utilized to mitigate overfitting problems [29,30].

Transfer learning, is a machine learning approach, which allows to use a pre-trained model for different tasks or domains [27-30]. In the literature, many studies having tasks with limited training data problem have utilized transfer learning [25]. Since it is allowed to use pre-trained models for the datasets from different domains, transfer learning is preferable for most problems where collection of data/data acquisition is difficult [25]. In this paper, transfer learning is deployed for landing page component segmentation, as the labelled dataset for landing page components is limited.

Due to the design limitation of these components, collecting a vast amount of data was a hard issue. In order to

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handle this problem, transfer learning including CNN and Support Vector Classifier (SVM) has been used. There are many studies combining CNN and support vector methods to classify images [21]. After extracting features from the images using CNN, performing classification by SVM yields remarkable results [20,21]. In some cases, it is observed that combining CNN and SVM performs better in image analysis than using either one of the methods [22].

2. LANDING PAGE COMPONENT CLASSIFICATION USING TRANSFER LEARNING

The proposed image analysis method to detect components of landing pages consists of two steps. In the first stage, landing pages obtained as digital images are segmented based on morphological operations and thresholding [19]. In the second stage of the proposed method, each image segment is assigned to one of the ‘Button’, ‘Text’, ‘Checkbox’ classes by SVM, which are the most common components of a landing page. The flow chart of the proposed method is presented in Figure 2 whose details are described below.

2.1. Detecting Landing Page Components with Image Segmentation

In this stage, the single channel gray level image (Y - brightness component) is obtained from the three-level Red, Green, Blue (RGB) image belonging to the landing page [15]. Morphological gradient operation is applied to the gray level image by using 3x3 dimensional elliptic structuring element in (1). Afterwards, Otsu thresholding is applied to the obtained gray level output image to binarize it.

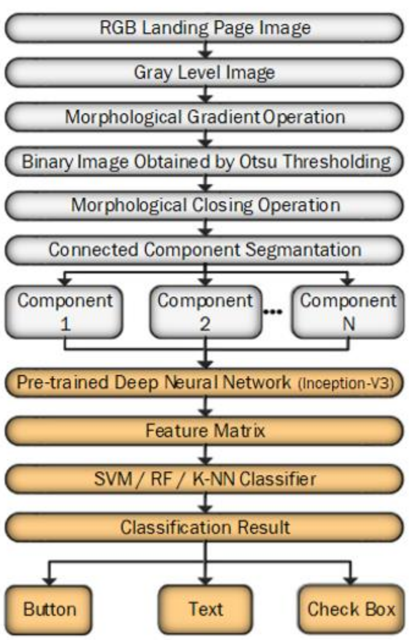

Fig.2. Steps of the proposed method to classify and segment the components of landing pages. Digital landing page images obtained as inputs are segmented based on morphological image processing operations followed by thresholding. Each candidate component obtained from segmentation is assigned to one of the ‘Button,' ‘Text,' ‘Checkbox' classes, which are the most commonly used components in landing pages.

The binary image is separated into its candidate segments by using connected components after applying morphological closing operation. The 10x2 rectangular structuring element determined by the common features of the landing page components is used in morphological operation [17]. A sample landing page image is shown in Figure 3, while the candidate components of the same landing page is presented in Figure 4.

$$M = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{bmatrix}. \tag{1}$$

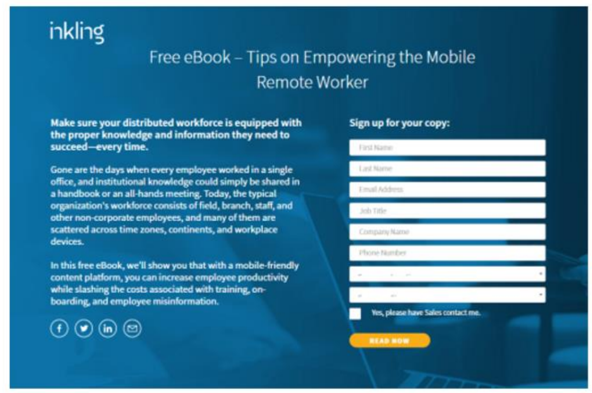

Fig.3. A sample landing page image

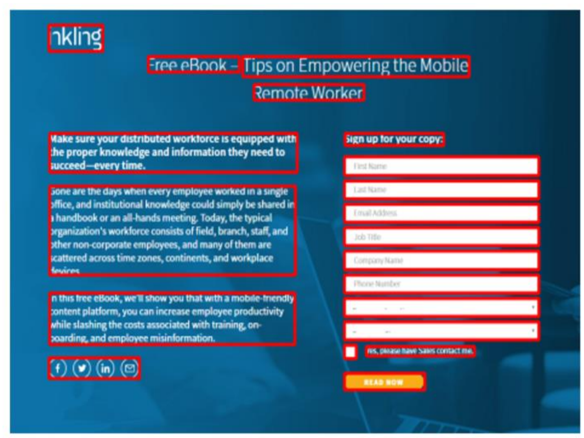

Fig.4. Candidate components of the landing page image in Fig. 3, obtained as a result of the processes in the first part of the proposed method. Respective components are assigned to one of the classes "Button", "Text" and "Checkbox".

2.2. Classification of Segmented Components with Transfer Learning Based Approach

In order to make the system automatically identify which one of ‘button’, ‘text,' ‘checkbox' classes do the segmented components belong to, a transfer learning-based approach including CNN and SVM classifier is used. First of all, the features were extracted from the images by using a pre-trained CNN network. Afterwards, different classifiers were trained for classification. From the results obtained, SVM Classifier was selected as the best performing classifier.

2.2.1. Feature Extraction

Inception-v3, one of the pre-trained deep learning models developed by Google, was re-used for our datasets consisting of segmented button, text and checkbox components of landing pages [28-30]. As the last layer (fully connected layer) of the Inception-v3 corresponds to the classification part of CNN model, it is eliminated from the architecture to establish different classification models instead.

Convolutional layers have been used to determine and extract the relevant features of images and classification has been carried out by fully connected layers in image classification using deep learning. In our study, the classification was carried out by transfer learning. Inception-v3 deep CNN model, which has been trained for ImageNet Large Visual Recognition Challenge using data from 2012, has been re-used for our dataset to extract features of size 2048 [28-30]. Since, the model has already been trained with a huge dataset, using its pre-calculated weights on a different dataset with small size as ours, has been very beneficial to easily extract features with a very small amount of time and cost. Inception-v3 model was used until it's last fully connected layer.

TABLE I
THE NUMBERS OF TRAINING AND VALIDATION DATA SETS BELONG TO EACH CLASS

Components	Number of Training Set	Number of Validation Set
Button	48	12
Checkbox	48	12
Text	56	14

The output obtained by the restricted Inception-v3 model has become the input that is fed to the SVM classifier.

The model was trained with the numbers of training data and validated using five-fold validation, as shown in Table I.

After the features acquired using Inception-V3 model, dimensionality reduction was applied to extracted feature vector by an unsupervised machine learning approach, t distributed stochastic neighbor embedding (t-SNE). Applying dimension reduction to the feature vector reduces dimension from 2048 to 2. Therefore, visualization of features in a lower dimensional space is provided (cf. Fig. 5). According to the figure, buttons (red), checkboxes (blue), and text (green) are well separated from each other.

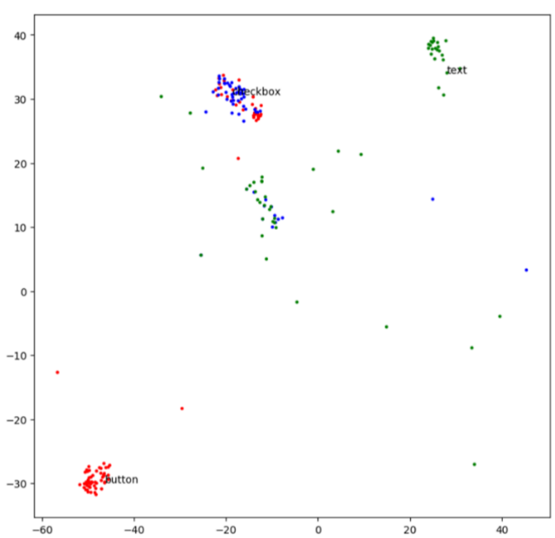

Fig.5. Demonstration of features in 2-dimension space by t - SNE.

TABLE II
ACCURACIES OBTAINED FROM SVM, KNN AND RF CLASSIFIERS ON VALIDATION SET

Classifier Type	Accuracy
SVM	97.6%
KNN	97.5%
RFF	96.6%

2.2.2. Image Classification

After extracting the features, each of SVM, Random Forest Classifier (RF) and K-Nearest Neighbors Classifier (KNN) were trained to classify and results were compared. For the output images obtained after the last pooling layer of Inception-v3 CNN model have set as inputs of related classifiers. For small-sized component datasets SVM yields better results than the other classifiers. Consequently, in our implementations, we utilize SVM.

3. EXPERIMENTAL RESULTS

In the second part of the proposed method, the Transfer Learning-based approach was performed after components of Landing Pages were segmented in the first part. Obtained components, which were segmented from the pages, are used as datasets in Transfer Learning. At first, the feature extraction was performed by pre-trained Inception v-3 model on this dataset. Secondly, classifiers including SVM, RF, KNN were trained on the extracted features of the dataset. After identifying features and their corresponding ground-truth labels, training was performed with 80 percent of the dataset being allocated as the training set while 20 percent of the is used as validation set.

The number of training and validation images is indicated in Table I and representative images used in training and validation sets are shown in Figure 6.

Fig.6. The representative images of button, checkbox, text classes used in validation and training data sets.

After performing classification using SVM, RF and KNN classifiers, it is observed that the best result was achieved by

SVM classifier with an accuracy of 97.6% Accordingly, SVM classifier has been determined as the final classifier to detect the class of Landing Page components. It is observed that the accuracy scores for the other classifiers are reasonably acceptable for a classification problem. Results of accuracies for each classifier are given in Table II.

4. CONCLUSIONS AND FUTURE WORKS

In this study, image analysis methods based on morphological operations, thresholding and transfer learning method based on CNN and SVM is presented to automatically segment the landing pages used in online advertising applications, to separate them into the three most commonly used components on the page and to recognize what the components are. In the proposed method, collected dataset for training is not an easy task because the components of landing page designs do not differ from page to page. The proposed method has prevented the problems related to small data.

For feature work, re-evaluation of the approach in such a way to classify the properties of the segmented components with respect to color, font, and size will be considered. Thus, the human factor in the designing process of the landing pages can be minimized, and the cost can be significantly reduced.

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