DEFINING THE MAIN FEATURES OF CLOTHING TO APPLY DEEP LEARNING IN APPAREL DESIGN

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Abstract: *The paper is devoted to defining the features of clothing to apply deep learning in apparel design. The images of women's outerwear were selected with the help of reverse image search. The images of women's duffle coats, coats and suit jackets were selected. The selected material was sampled for the next categorical principal components analysis and general assessment of differences that are caused by specific features of garments. It was revealed that similarity search might be used to perform the selection of models to define the typical design solutions. However, a process of defining the solutions cannot be automated yet. The indicators of clusters, which were revealed in the result of the categorical principal components analysis, define the structure of the database for the deep learning. Based on the results of performed online survey, it was considered advisable to use as labels specific features of the particular garment type rather than its name. Each label refers to one of the main features of a garment type.*

Keywords: *deep learning; garment type; features of garment; similarity search.*

1 INTRODUCTION

Although clothing design is one of the most creative realms in the contemporary world; it is a highly developed technological industry as well. However, the great part of designer's work is not performed with the help of computers. Whether it is because of considerable creative part of design process or equivocal information about clothing, the fact remains to be.

Internet shopping has incredibly increased in the last years, and fashion created an interesting application field for image understanding and retrieval, since hundreds of thousands images of clothes constitute a challenging dataset to be used for automatic or semi-automatic colour analysis, texture analysis, similarity retrieval and so on [1]. Such tasks are performed with methods of machine learning, part of which is deep learning. Deep learning trains a computer to perform human-like tasks, such as recognizing speech, identifying images or making predictions [2]. Instead of organizing data to run through predefined equations, deep learning sets up basic parameters about the data and trains the computer to learn on its own by recognizing patterns using many layers of processing.

Fashion is an entirely new direction for machine learning, but it is far from to be an exception from the list of possible applications. The opportunities for deep learning in the fashion domain are very versatile. Researches all over the globe work with algorithms of machine learning, which are universal and therefore, it is possible to use them for the purposes of apparel design and fashion industry. For example, the results, which were described in [3], allow the user to translate the image into the text that might as well be interpreted as a description of the garment, based on its sketch.

Authors of [4] suggest that in the domain of visual search, with a focus on image similarity for online shops, understanding images of clothing means more than just classifying them into coarse categories. In order to get a meaningful description of the whole image, one needs to decompose the image into its parts. In addition, to train the machine to recognize the clothes, it is required to use a large dataset because of the great number of apparel categories [5]. Furthermore, in contrast to other domains, fashion images are usually annotated with one or more categories (labels) since these pictures are often used directly in some kind of online shop or catalogue website or fashion portal. The report [6] says that the number of global online shoppers will grow by 50% from 2013 to 2018, from 1.079 billion to 1.623 billion. Clothing is the most frequently purchased online category of goods. Furthermore, according to [7] the growth of the global women's apparel market will accelerate, driven by a shift to the faster growing, emerging markets. It shows that there is a wide range of possibilities to develop the online searching techniques. Thus, fashion industry is the market, which has great future in the area of computer vision [8, 9].

However, fashion and apparel design are not exactly the same. Apparel design focuses on the garment manufacturing while fashion is concentrating on the clothing distribution. Hence, the application of deep learning in apparel design means to be of help for a patternmaker while deep learning in fashion is a help for a consumer or a fashion retailer. Thus, available fashion search engines are to be examined in order to determine the extent of their possible applications in domain of apparel design rather than fashion.

Fast and accurate fashion item detection model, based on deep neural networks, was proposed in [9]. Results, obtained by authors, make it possible to use their model for the task of fashion item detection and recognition, followed by visual similarity search.

To design clothes, one should know and understand the mechanisms of fashion: causes and spreading of the trends, principles of cyclic repetition and evolution patterns. Considering all of the above, designers develop the fashion of tomorrow. The authors of [4] suggest that now the task of designing or predicting trends can be simplified, thanks to a new class of neural networks. These networks can automatically allocate shapes, elements and types of clothing and further combine them.

The dashboard, developed by [5], allows seeing "how frequently a particular type of garment appears per day, what kind of apparel is popular within a certain age range, how people match their garments, etc." Authors [5] developed the graph showing the predictions of how popular certain types of garments would be over the next season that could be up to five months. This kind of analysis aims to help fashion retailers plan sales and avoid any surplus.

Snap Fashion [11, 12] is one of the first projects in this area. It has already been several years on the market. The accuracy of search is low though. It is based mostly on the item's colour.

Project ASAP54 [11, 13] allows one to find an item by its colour taking into account several additional characteristics, which are to be ascribed by user.

IPhone App "Take pictures of clothes" [14] allows one to search the items by computer vision technologies developed by Yandex. The process is as follows: an algorithm defines the garment in the image, and then it compares similar pictures, which are available in the web, and at last, it provides the user with the images of items, which have the most similar appearances to the original image.

«GETSARAFAN» [11, 15] is the project that is still under development. The main issue of the project is so called semantical gap. It means there is a difference between machine perception of an image and human perception of the same image. The main idea of the project is to label an enormous set of garment images with specific labels, teach the classificator, and to classify the segmented images in that way.

Above mentioned projects have a common purpose, that is so called «similarity search», which allows finding the images that are similar to the original image by its general characteristics such as dimension, number of pixels, colour.

The result of such search is the list of items, which make the same impression as the original garment. However, these items differ by their design characteristics. Therefore, they even might belong to different garment types [16, 17]. It is unacceptable situation for the clothing designer.

2 DISCUSSING IDEAS

Modern pattern design systems relay the functions of clothing designer to a computer user. Presence of two design subsystems in such software, the first one aims at creating the sketch and the other one at drafting the garment construction, allows designing the garment in complete accordance with the original idea.

In the era of global digital technologies, most of the sketch creating subsystems most likely can be used for searching through the catalogues of apparel garments in the Web as well as for the review of online fashion shows in order to forecast the fashion tendencies and retrieving of the most frequently used elements of the fashionable outfits. Google Images is a search service owned by Google. It allows users to search the Web for image content and most likely can be used for the garment search as well. According to [2], the question of differences between the specific garments types might cause misunderstandings in design process due to the ambiguous definitions that lead designers to the completely different appearances of the garments.

Deep learning is a popular means of new era of technology that provides ability to exclude human factor and differences in experts' opinions from specific steps of design process. The supervised learning is the task of inferring a function from labelled training data that consist of a set of training examples. Deep learning in apparel design means that the training examples are labelled pictures of garment types. Differences in definitions of garments types especially in different languages are the obstacles in the way of successful online search, preparing technical documentation [18], development and implementation of expert systems and other elements of artificial intelligence in apparel design [19]. Therefore, in order to make a qualified fashion review or perform an online searching of specific garments with keywords, it is necessary to determine the description of each garment type and its main features.

3 METHODS

In order to investigate the possible applications of deep learning in domain of apparel design, it was determined to use the methods of online surveys as well as methods of statistical analysis and data mining. A set of images, which display a particular garment type, was obtained with Google reverse image search. Consumer impressions from clothes, which were found by similarity search with tools of Google Images, were assessed with the help of method of semantic differential, which is described in [18, 21]. Categorical principal components analysis was used to graphically display the relationship between the garment features that result in significant differences in appearances or impressions of the garments, which were found by similarity searching. The chosen method optimizes distances between objects and it is very useful for the primary interest is difference or similarity between the objects.

4 EXPERIMENTAL

Online survey that was performed through social networks in order to determine the name of the specific garment type, which is a duffle coat, shows that experts, whose area of expertise is clothing design, are not able to perform the task unanimously or even within statistical error (Figure 1). The expert group consisted of 67 experts.

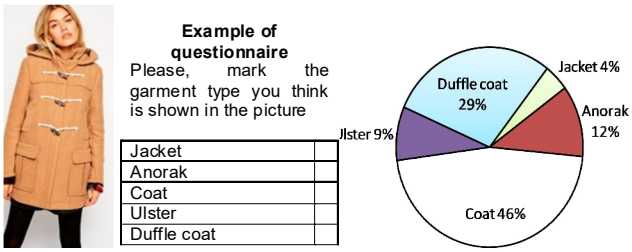


Figure 1 Results of the survey in the social media

As it can be seen in the Figure 1, only 29% of examined group were able to recognize a duffle coat in the image. Hence, it is advisable to use as labels specific features of the particular garment type rather than its name because the features are standard and can be determined specifically.

In order to reveal the prospects of utilizing the similarity search in the domain of apparel design actual image search was performed by tools of Google Images (Figure 2). The original image of duffle coat is the same that was used for the online survey (see Figure 1). Original images of coat and suit jacket are presented in the Figure 3. As it is displayed in the Figure 4, only half of the found images might be of any aid for the designing purposes, for the other half contains the images of different types of women's coats that are not the duffle coats.

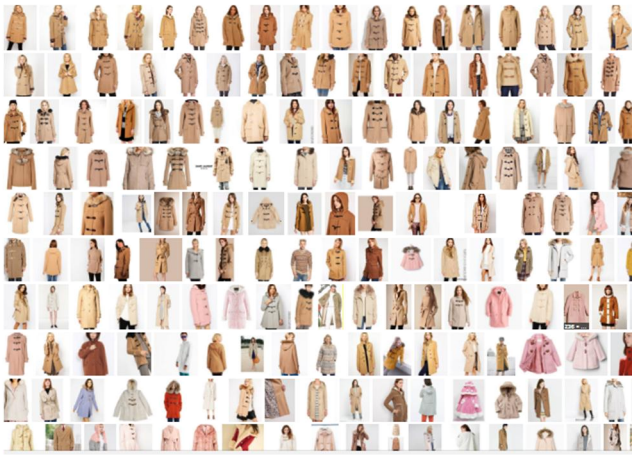


Figure 2 Results of the search by image algorithm of Google images (a fragment)

Figure 3 Original images of coat and suit jacket

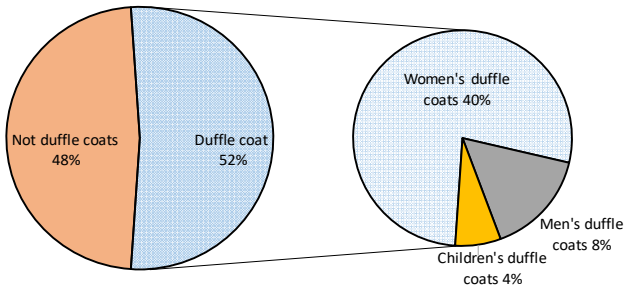


Figure 4 Quantity analysis of the images

While searching images of coats, it was discovered that only 53.9% meet the requirements, and actually, are coats. Among them 97.4% of images are women's garments, 1.55% – men's garments, 1.05% – clothes for children. Among presumably images of suit jackets, only 70.61% are actually women's suit jackets, 27.19% – men's suit jackets, 2.2% – clothes for children.

For the next step of current research, the number of examined items decreased to the number of actual women's duffle coats. In order to use categorical principal components analysis, which would be performed with tools of the package PASW Statistics [22], every single garment was described with a code, which consisted of Arabian numerical codes

of certain features of the garment (Table 1). The list of the considered features is as follows: silhouette (S), length (L), form (F), toggle-fastenings (TF), fastenings (Fs), yoke (Y), pockets (P), hood (H), trimming (T), collar (C), seams (Ss), Cut (Cut). A garment, which was the origin of the search, has a code like follows: 1.2.1.2.1.1.5.1.6.1.1.1. The other ones were coded according to the developed code system, example of which is displayed in the Table 1.

Table 1 Example of the Code System

Code	Collar	Code	Hood	Code	Form
1	No collar	1	Stitched hood	1	Rectangular
2	Convertible collar	2	Stitched hood with fur	2	Trapezoid (long base down)
3	Standing straight collar	3	Removable hood	3	Oval
…	…	4	Removable hood with fur	4	X-shaped
…	…	5	No hood	…	…

The list of considered features of coats is as follows: silhouette (S), length (L), form (F), buttons (B), Cut (Cut), collar (C), pockets (P), seams (Ss), additional details (AD), fastening (Fs), hood (H). Considered features of suit jackets are as follows: silhouette (S), length (L), form (F), buttons (B), Cut (Cut), collar (C), pockets (P), seams (Ss), additional details (AD), fastening (Fs). Each feature is presented in the numerical codes of garments' images.

The procedure of categorical principal components analysis simultaneously quantifies categorical variables while reducing the dimensionality of the data. Two most important components, which show the combined impact of all considered features, were selected out as dimensions for the graphical visualization of the results of the current research. The most important dimension 1 refers to the component 1 that is "form" (for the duffle coats, coats, and suit jackets) and the second one, dimension 2, refers to the component 2 that means "fastenings" (for the duffle coats) or "buttons" (for the coats and suit jackets).

Besides that, photos of clothes were valued using valuation factors in bipolar scales defined by verbal antonyms of Kansei words, which were described in [18, 21]. Thus, each image was represented as a list of the average meanings of the estimated coefficients of semantical differential, which is called psychographic profile, for six pairs of Kansei words: symmetry - asymmetry (SA), bright – soft (BS), casual – smart clothes (CS), transparent – non-transparent (TN), folk – modern clothes (FM), trapezoid shape (long base down) – trapezoid shape (long base up) (TdTu). The garments, which were the origins of the search, have profiles like follows: -3.0.-1.3.-2.-3 (duffle coat), -3.1.0.3.-2.3 (coat), -3.-2.0.3.-1.3 (suit jacket). The procedure of categorical principal components analysis allowed selecting two dimensions as well as estimating the loadings of the principal components (table 2). The components are TdTu and BS (for the duffle coats), CS and TN (for the coats), and CS and TdTu (for the suit jackets).

Table 2 Loadings of the Principal Components (Impressions)

Component	TdTu	BS	FM	CS	TN	SA
1	0.970	-1.240	1.191	1.354	-0.437	0.280
2	-0.885	0.538	0.947	0.518	1.489	1.243

5 RESULTS

Objects plots (Figure 5) display the differences between clusters of images. Objects are labelled by the category indicator values. One object plot is produced per variable, which is the feature of garment.

Each graph in the Figure 5 displays two clusters that differ significantly by one of the follows features: F, SS, C, or H. The form and the style seams are the features that cause the change of garment draft and the style. Particularities of the collar and hood cause differences in assembly techniques and a marker for the cutting. The size of each cluster that differs is considerable in comparison to the general size of the examined population of images. The number of items, which differ by features of the collar and hood, is 26 garments that is about 25% of the population of examined images of the duffle coats. The number of items, which differs by features of the form and style seams, is lesser. It is only four items for the form and eight items for the style seams, which compose a small cluster of ten images. It is about 10% of the population of the duffle coats. However, because of all these differences a considerable part (about 72%) of the original population of the search results, which are displayed in the Figure 6, is no use for the garment industry.

Similar results were obtained for the other garment types. About 19% of images differ from the majority by the feature "silhouette", 13.8% – by the feature "form", and 25% – by the feature "cut". About 22.4% of images of suit jackets differ by the feature "silhouette", 14.9% - by the feature "form", and 11.8% – by the feature "buttons". On the other hand, the graphs in the Figure 6 display that all found images of the duffle coats cause the similar consumer's impressions from clothes. Several items, which differ from the main cluster by certain impression like TN "transparent – non-transparent" (Figure 6a) or "trapezoid shape (long base down) – trapezoid shape (long base up)" (Figure 6b), compose a small proportion that is insignificant in the general population of examined images. The part of each one is about 3% and 2% respectively. The same goes to the results of analysis the images of suit jackets and coats (Figures 7 and 8).

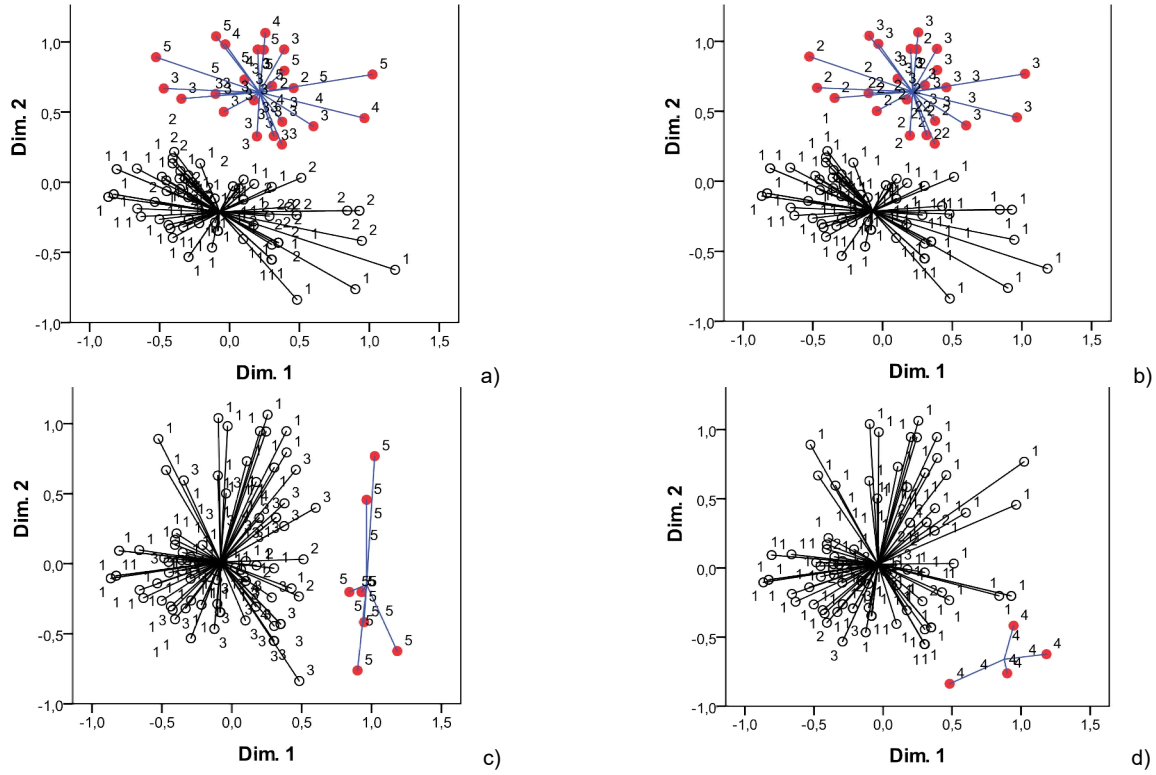


Figure 5 Results of the Categorical principal components analysis based on codes of garments: a) hood; b) collar; c) style seams; d) form

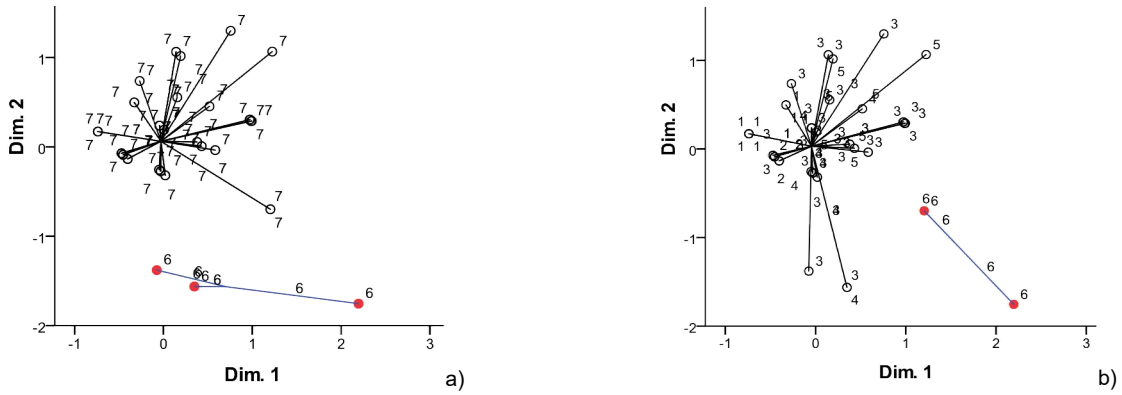


Figure 6 Results of the Categorical principal components analysis based on consumer's impressions of duffle coats images: a) TN; b) TdTu

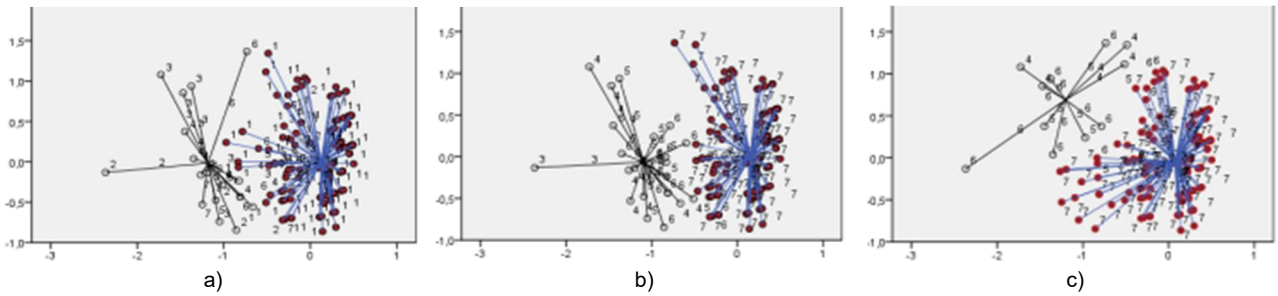
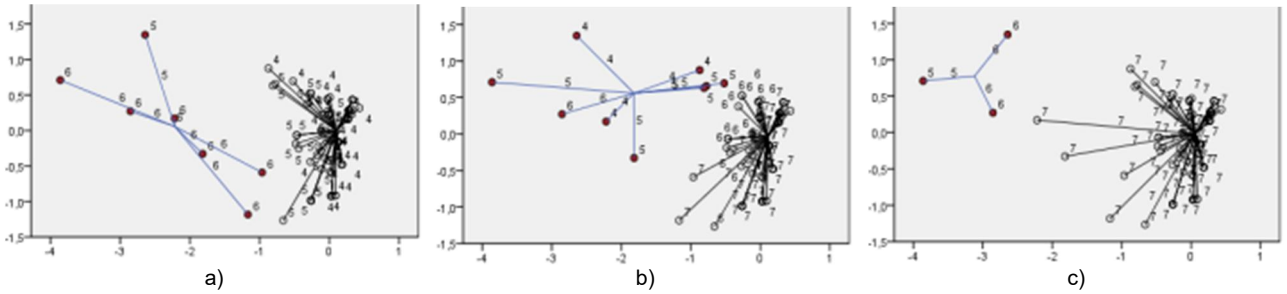


Figure 7 Results of the Categorical principal components analysis based on consumer's impressions of coats images: a) SA; b) TN; c) FM



a) b) c)

Figure 8 Results of the Categorical principal components analysis based on consumer's impressions of suit jackets images: a) TdTu; b) TN; c) FM

Therefore, it is impossible to disagree with the statement of [22] about the need to consider every single fashion item as a whole concept that has to do with human perception of contemporary world.

6 CONCLUSIONS

As a result of the current research, it was displayed that the task of organizing the database of properly labelled images of garments is the first step to performing automatic fashion reviews, online searching and forming descriptions of garments. Based on the results of performed online survey, it was considered advisable to use as labels specific features of the particular garment type rather than its name because the features are standard and can be determined specifically.

Analysis of images of outerwear, which were obtained with the help of reverse image search, was conducted. The images of women's duffle coats, coats, and suit jackets were selected. The selected material was sampled for the next categorical principal components analysis and general assessment of differences that are caused by specific features of garments.

It was determined that less than 30% of original population of images were sampled with required level of accuracy. However, all found images of the certain clothing types cause the similar consumers' impressions. Hence, although it is certain that deep learning has great future in domain of apparel design, for now it can be used only for the purposes of similarity search for the online shops, which are oriented to the consumers' impressions rather than to retrieving the features of fashionable outfits.

Similarity search might be used to perform the selection of models to define the typical design solutions. However, a process of defining the solutions cannot be automated yet.

Thus, there is a need to form a database for the deep learning in apparel design. Such database must consist of the images, which are labeled with a set of labels. Each label refers to one of the main features of a garment type. Furthermore, it is important to form different databases for the different garment types. The structure of such databases must correspond to the indicators of clusters, which were revealed in the result of the categorical principal components analysis.

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