Recommender System for Cosmetics Based on User Evaluation and Ingredients Information

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Abstract: In recent years, the number of cosmetic review sites, users, and products posted have been increasing year by year. For example, when a user searches for skin lotions using *@cosme* website, she reads reviews written by users who have similar attributes to herself (age, skin quality, etc.) and searches for items that are compatible with the skin lotion that she uses on daily basis. However, since different basic cosmetics may have different effects, it is difficult to find products that are compatible with a user even using the review information in *@cosme* website. In this study, we assume that the compatibility between a user and a basic cosmetic product depends on its cosmetic ingredients. Using review information of *@cosme* website and ingredient information of *Bihada-Mania* website, we extracted a valid cosmetic ingredient for each user attribute and developed a recommender system of basic cosmetics based on ingredients.

Key words: Natural language processing, Recommender system, Review information, Cosmetic ingredient information.

1 Introduction

In recent years, web services have been become popular in our daily lives, and many consumers refer to user reviews of products when considering purchases. *Kakaku.com*[1], *Minna-no-Cinema*[2], and *@cosme*[3] are popular major product review sites, focused on home electronics, movies, and cosmetics, respectively. The number of cosmetic review sites, users, and products posted have been increasing year by year. For example, when a user searches for skin lotions using the *@cosme* website, she reads reviews of users who have similar attributes to her own (age, skin quality, etc.) and searches for items that are compatible with the skin lotion that she uses on a daily basis. A user who feels she has dry skin looks for a skin lotion with a high moisture effect. A user who is interested in skin whitening selects products with many reviews that argue they are effective for whitening. However, since different basic cosmetics may have different effects, it is difficult to find products that are compatible with a user, even using the review information from *@cosme*. Conventionally, the recommendation services of review sites are mainly based on collaborative filtering [2, 8]. They are built on recommender systems based on the similarity among users and the browsing page. Recommender systems using collaborative filtering are mainly based on the black box approach. The black box approach does not indicate the interior mechanisms of the recommendation procedure, and the reasons for recommendations are not obvious [4]. A recommendation function is also installed in the *@cosme* website, but the reason why the recommended product has been chosen is not disclosed.

On the *Bihada-Mania* website, the ingredients of cosmetics on the market are presented. In this study, we assume that the compatibility between a user and a basic cosmetic product depends on its cosmetic ingredients, which are available from *Bihada-Mania*. Using review information from *@cosme* and that from *Bihada-Mania*, we extracted the effective cosmetic ingredients for each user attribute and developed a recommender system of basic cosmetics based on ingredients. The product categories covered in this research were skin lotion of basic cosmetics, which represent the largest number of products in cosmetics. As a first step of our research, we consider exactly one effective ingredient for each lotion. Considering more than one effective ingredient is left for future work.

The number of studies on recommendation methods using website review information is increasing [7, 5, 1, 3]. However, research on recommendation services paying attention to ingredients of cosmetics has not been presented as far as we know.

2 @cosme and Bihada-Mania Website

We introduce the two sites related to this research.

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[1]Kakaku.com: http://kakaku.com
[2]Minna-no-Cinema: https://www.jtnews.jp
[3]@cosme: http://www.cosme.net/

2.1 @cosme Website

The *@cosme* website is the largest-scale website in the field of cosmetics in Japan. As of May 2015, the site had 3,200,000 users, approximately 12,000,000 reviews, 28,000 brands, and 250,000 products. The number of reviews posted is increasing year by year. Users refer to the purchase of a product and its usage. Users registers their information such as age and skin quality at the time of registration.

At *@cosme*, the user evaluates the recommendation degree for each product as follows.

0. Very dissatisfied
1. Dissatisfied
2. Not good
3. Average
4. Pretty good
5. Good
6. Very good
7. Excellent

Moreover, users can freely write a review within 2,000 characters. As another evaluation method, the user can arbitrarily select the effect tag and add an arbitrary number of tags. The tags available for selection depends on the category of the product under review. The type and number of selectable tags differ depending on the product category. The image of a review of *@cosme* is shown in Fig. 1.

In case of skin care / basic cosmetic product, users can select tags such as [moisture], [acne], and [whitening] and in case of a makeup item, they can select [coloring] or [color] tags. There are 15 types of effects tags that can be used when posting reviews on skin lotions, as shown below.

- Moisture
- Pores
- Acne
- Whitening
- Mild stimulation
- Anti-Aging
- UV cut effect
- Skin elasticity
- Refreshing feeling
- Horny care
- Oily
- Tightening
- Cleansing
- Cost performance
- Organic cosmetics

2.2 Bihada-Mania Website

The actual product contains ingredient information. In addition, the user can acquire ingredient information by viewing the homepage of the maker. However, manufacturers are not obliged to disclose product ingredients on their website. The user must obtain the product in order to know the ingredient information of the product. Therefore, it is difficult to comprehensively acquire ingredient information for all products. The *Bihada-Mania* website responds to the needs of users who want information on the ingredients of products. *Bihada-Mania* is the largest site in Japan that publishes cosmetic ingredient information and toxicity judgments. As of December 20, 2016, cosmetic ingredient information on 30,576 products has been posted. *Bihada-Mania*, as shown in Table 1, presents both ingredient information and toxicity.

3 Proposed Method

The purpose of this research is to realize a system that extracts ingredients presumed to have high cosmetic effect and recommends cosmetics containing them using user rating on a cosmetic review site. We realize the following functions.

1. Define user categories with similar skin quality.
2. Extract the evaluation of skin lotion for each user attribute.
3. User's evaluation on a cosmetic effect is extracted for each skin lotion.
4. Acquire all ingredients contained in skin lotion group X with high beauty effect.
5. Extract ingredients that characterize facial skin lotion group X.
6. The skin lotion containing the ingredients derived in Step 5 is output as the recommended product group.

In 1), user categories are classified using user attributes. In 2), we aggregate the effect tags attached to reviews from the *@cosme* website for each user attribute, and assign the value to the evaluation of the

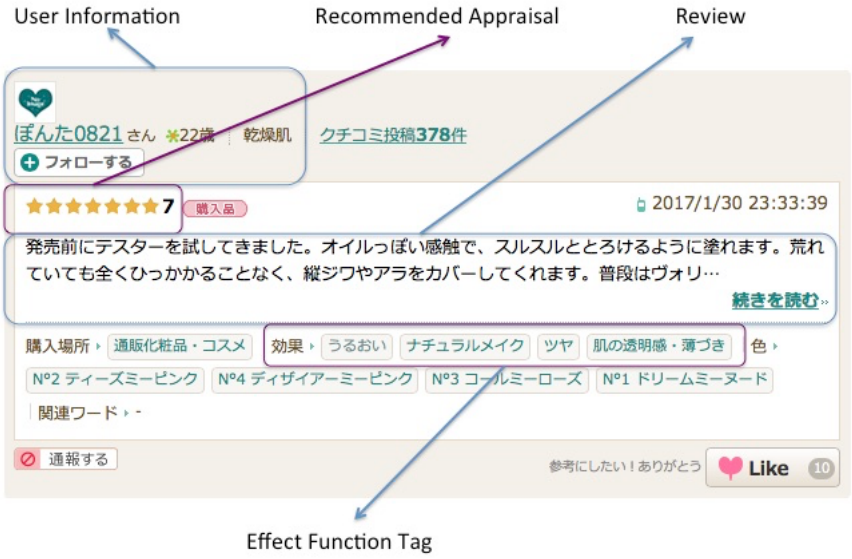

Figure 1: Review of *@cosme*

cosmetic effect of cosmetics. In 3), the operation 2) is performed for all the skin lotions. In 4), skin lotion group X is derived by setting a proposed threshold. The ingredient is extracted from the *Bihada-Mania* website. 5) is done using an ingredient extraction method that characterizes cosmetics. The cosmetics to be recommended in 6) are those containing the ingredient derived in 5) and registered on *Bihada-Mania* website.

3.1 User Attributes

All users set one skin quality and one age at the time of user registration. The user attribute in this research is defined by information of the set skin quality and age. For user attributes, we consider 72 classes composed of combinations of six skin types (normal, oily, mixed, dry, sensitive, and atopic skin) and 12 age groups (14 years or younger, 15–19 years old, 20–24 years old, 25–29 years old, 30–34 years old, 35–39 years old, 40–44 years old, 45–49 years old, 50–54 years old, 55–59 years old, 60–64 years old, and over 65 years old).

3.2 Usage Data

Usage Data is crawled from *@cosme* and *Bihada-Mania* websites in advance. Product categories are skin lotion in skin care and basic cosmetic products. The target shall be a product corresponding to the category of skin lotion listed on both the *@cosme* and *Bihada-Mania* websites. Currently, 1,051 products are applicable.

3.3 Threshold Setting

For each cosmetic product, we derive a skin lotion with a high proportion of cosmetic effect tags. As a method of determining the threshold, a natural classification method was used. We examined the number of products with effect tag and the number of reviews of each product and adopted those two change points as thresholds. As a result of this experiment, we set the threshold to 40%. We define a group of products with effect tags (eg. “Moisture” tags) attached to users of 40% or more as a highly effective cosmetics group and denote as X.

3.4 Ingredient Extraction Method

The highly effective cosmetics group X is a product set in which a certain user attribute is evaluated as having a high cosmetic effect. When considering the ingredient characterizing a certain highly effective skin lotion group X, we estimated that the ingredient with high content would characterize its X. However, many skin lotions contain water and BG (1,3-Butylene glycol), and these ingredients do not characterize the product. We apply the concept of TF-IDF, which is used to find a word that characterizes sentences, and propose a method to find ingredients that characterize highly effective skin lotion group X.

IF (Ingredient Frequency)

IF (Ingredient Frequency) is the proportion of content of ingredient i included in the highly effective cosmetics group X. There is a rule that the ingredient indication of cosmetics is described in descending order of blending amount. We consider that the in-

Table 1: All ingredients of a product "Skin Conditioner Essential"

Ingredient	Utility
Dipotassium glycyrrhizate	Flavor, Anti-inflammation
Purified water	Solvent
Ethanol	Solvent, Solubilizer, Astringent
1,3-butylene glycol	Moisturizing, Solvent, Reduced viscosity
Glutathione	Perfume, Reduction, Whitening
Adlay essence	Oil, Protective agent, Whitening
Hamamelis	Fragrance water, Astringent, Moisturizing
Marronier extract	Moisturizing, Washability
I-menthol	Flavor, Perfume
Carrageenan	Perfume, Hydrophilic thickener
Sorbitan sesquioleate (toxicity)	Synthetic surfactant, Emulsifier
Polyoxyethylene hardened castor oil (toxicity)	Synthetic surfactant, Emulsifier
Absolute ethanol	solvent, Solubilizer, Astringent
Parahydroxybenzoic acid esters	Preservative
Perfume	Perfume

gredient with high content characterizes X. We sort ingredients in descending order of their content. IF is given by the following equation. In ingredient with high content ranking, the IF value becomes high.

$$IF(i, X) = \sum_{p=1}^{m} \frac{n_p - \alpha_{p,i}}{n_p} \tag{1}$$

n_p **:** The number of ingredients included in product p in skin lotion group X.

m **:** The number of products in skin lotion group X.

$\alpha_{p,i}$ **:** Rank of ingredient i listed in product p.

IPF (Inverse Product Frequency)

IPF (Inverse Product Frequency) is the reciprocal of the number of products containing an ingredient. For example, "water" used in many products has a lower IPF value. IPF is given by the following equation:

$$IPF(i) = \log \frac{N}{pf(i)} \tag{2}$$

N **:** The number of skin lotion products

$pf(i)$ **:** The number of products including ingredient i

IF-IPF

IF-IPF is given by the following equation:

$$IF\text{-}IPF(i, X) = IF(i, X) \times IPF(i) \tag{3}$$

Comparison of frequency, IF value, and IF-IPF value

For verification, the frequency, IF value, and IF-IPF value are respectively derived and compared. For skin lotion group X. which was given 40% or more of the effect tag "Moisture" by the user attribute "normal skin : 25-29 years old", we show the top six ingredients of (1) Frequency, (2) IF value, and (3) IF-IPF value, respectively. There are 151 products in skin lotion group X.

(1) Frequency

Water	116
BG	105
Ethanol	102
Glycerin	95
Phenoxyethanol	89
Quenic acid	83

(2) IF value

Water	3.06
Glycerin	2.62
BG	2.31
Ethanol	1.97
DPG	0.89
Dipropylene glycol	0.80

(3) IF-IPF value

Dipropylene glycol	2.28
3-butylene glycol	1.88
DPG	1.81
Xylitol	1.77
Purified water	1.51
Concentrated glycerin	1.50

From the results of (1) - (3), using (3) IF - IPF value, ingredients characterizing the product group X can be extracted. This is because the importance of ingredients (for example, "water") contained in many

products can be reduced.

3.5 Proposed System

The flow of our method is described below.

Input: User attribute, effect tag (s) to be verified, thresholds Min 0, Max 1.

Output: Product containing ingredients with high IF-IPF value.

Step 1. Build a database using crawled data from *@cosme* and *Bihada-Mania*.

Step 2. From among the products that the user corresponding to the user attribute posted review, we extract the product whose product category is the skin lotion.

Step 3. From among the products extracted in Step 2, we extract products with the number of users who give the specified effect tags equal to or greater than the threshold value.

Step 4. Extract all ingredients contained in the skin lotion group X extracted in Step 3.

Step 5. The IF-IPF value is calculated for the ingredient extracted in Step 3.

Step 6. Sort ingredients according to IF-IPF value.

Step 7. Output the product containing the top ingredient of the result of Step 6.

4 Experiment

For each user attribute, we extract an ingredient with high cosmetic effect of "moisture" and recommend a product containing it.

4.1 Method of Verification

The most important evaluation criterion in the recommender system is the level of satisfaction of the user with the recommended product [9, 6]. We have defined the scale "invalidated product number (IPN)" to evaluate the effectiveness of our recommendation service. IPN is the number of products that other users do not give any corresponding effect tag in cosmetics recommended by our system as having beauty effect.

When the ingredient i is expected to have a cosmetic effect "moisture" for a certain user attribute, the product group $(p_1, p_2, \ldots, p_n)$ including the ingredient i is defined as the recommended product group X. The number of products for which no effect tag "moisture" is attached in the review posted by the user attribute is defined as the invalidated product number.

4.2 Condition of Experiment

Using the proposed method, we conducted an experiment of recommending products containing ingredients presumed to have the cosmetic effect "moisture." The age group of most registered users in *@cosme* is the late 20s. Therefore, we target users of all skin types (normal, dry, oily, mixed, sensitive, and atopic skin) in the age range 25–29 years.

Next, we set the threshold of the IF-IPF value to certify the product with the effect tagged as actually having its cosmetic effect. If the setting of the threshold value is lowered, the ingredients of products not having high cosmetic effect may be extracted. However, when setting the threshold value high, an appropriate number of products is not extracted, so effective recommendation will not be possible. We changed the threshold and examined the relationship between the number of products extracted and the total number of reviews of each product. As a result, we could estimate based on natural taxonomy that the appropriate threshold is 40%.

4.3 Experimental Results

The results of Experiment 1 are shown in Table 2. For each user group, the top two ingredients in terms of the IF-IPF value evaluated as having a high "moisture" effect along with one product recommended from them are shown.

For each user attribute with different age and skin quality, the ingredients evaluated as having a high "moisture" effect are different. This can be verified using the number of invalidated products of each recommended product group. The number of invalidated products is less than 5% for all user attributes. This indicates that our recommender system has certain reliability.

As shown in Table 2, except for eucalyptus extract, ingredients with cosmetic effect are extracted as ingredients with high "moisture" effects. Camomile water and eucalyptus extract recommended for user attributes (sensitive skin: 25–29 years old) have anti-inflammatory and bactericidal effects. Users with sensitive skin tend to give cosmetic effect tags "moisture" to products including anti-inflammatory actions because they have more sensitive skin than others. The ingredient Rose Otto oil presumed to the user of atopic skin has anti-inflammatory action and skin tonic effect. Users of atopic skin tend to infer not only the moisturizing effect but also products with an effect of suppressing inflammation of the skin compared to other users.

Table 2: High "moisture" effect ingredients and recommended products containing those ingredients

User attribute	Products	Top 2 ingredients of IF-PDF value	Recommended products group	IPN
Normal skin: 25-29 years Number of users: 25,006	104	IF-IPF(dipropylene glycol) = 2.28 IF-IPF(1,3-butylene glycol) = 1.88	a_1: AQUALABEL white up lotion, and other 145 a_2: EVITA moisture lotion, and other 179	4/145 7/179
Oily skin: 25-29 years 17,441	99	IF-IPF(methyl gluceth-20) = 2.58 IF-IPF(dolabrata extract) = 1.65	b_1: EST eternal flow lotion, and other 34 b_2: ORIENA balancing lotion type2, and other 20	0/34 0/20
Mixed skin: 25-29 years 83,084	83	IF-IPF(DPG) = 1.62 IF-IPF(methyl gluceth-10) = 1.25	c_1: KEANA NADESHIKO rice lotion, and other 256 c_2: FANCL acnecare lotion, and other 57	14/256 2/57
Dry skin: 25-29 years 45,610	92	IF-IPF(DPG) = 1.88 IF-IPF(dolabrata extract) = 1.54	d_1: KEANA NADESHIKO rice lotion, and other 256 d_2: ORIENA balancing lotion type2, and other 20	6/256 0/20
Sensitive skin: 25-29 years 32,272	74	IF-IPF(chamomile water) = 2.48 IF-IPF(eucalyptus extract) = 1.49	e_1: Homeo Beau lotion, and other 5 e_2: MANIS skin lotion tea tree, and other 19	0/5 1/19
Atopic skin: 25-29 years 5,943	80	IF-IPF(rose otto oil) =2.11 IF-IPF(DPG) = 2.10	f_1: ANTIANTI flower aqua organics rose otto f_2: KEANA NADESHIKO rice lotion, and other 256	0/1 11/256

5 Conclusion

In this study, we assumed that the compatibility between a user and a basic cosmetic product depends on the cosmetic ingredients. We analyzed the cosmetic ingredients using the user's evaluation from the cosmetics site *@cosme* and extracted the ingredients presumed to have high beauty effect. Moreover, we implemented a system for recommending skin lotions containing extracted ingredients. User attributes were defined by a combination of skin quality and age, as submitted with *@cosme* user registration information. Furthermore, in order to evaluate the recommender system, the number of invalidated products was defined. The number of invalidated products is the number of products that are not cosmetic effective for the user. We collected information from *@cosme* and *Bihada-Mania* and constructed a system that recommends products with high cosmetic effects to each user attribute using this information.

From the experimental results, it is interesting to note that the compatible components were different for each user attribute. Since the proportion of invalidated product number of our recommender system was all 5% or less, it can be said that the proposed recommending system has certain reliability. If even one ingredient with high IF-IPF value is contained in the recommended product, the beauty effect for the product of the corresponding user attribute was high. By using other information in addition to age and skin quality as user attributes, the performance of the recommender system may be increased.

The future prospects include that the number of effect tags attached to reviews is used as user evaluation. By analyzing the text of reviews, it is possible to acquire highly reliable and effective components. Moreover, by extracting skin abnormality information, such as itching and swelling, from review text, it is possible to extract components that should not be used for each user attribute.

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