An E-commerce Recommender System Based on Degree of Specialties in Online Shops

Motoki Zaizen, Daisuke Kitayama, and Kazutoshi Sumiya

***Abstract*—Use of online shopping sites, such as Amazon and Rakuten, has increased in recent years. Many shops participate in these sites. The categories of shops represent various intended uses for listed items. For example, a flashlight is often used for camping or emergency items, so some shops use a category such as "Outdoors" or "Emergency Supplies" for that item. In this paper, we aim to build a recommender system for specialty shops based on the viewpoints of items browsed by users. We first extract viewpoints of browsed items by using category structures of online shops. Through this, we analyze the category structures and selection of goods to determine specialty shops.**

***Index Terms*—Online shopping, A recommender system, Category structures**

I. Introduction

USE of online shopping sites, such as Rakuten ichiba[1] and Amazon[2] has increased in recent years. These sites have category structures for classifying items based on their intended uses. For example, a flashlight used for camping has the category "Outdoors." Online shopping sites recommend various items based on users' item browsing histories, using a Collaborative Filtering method. However, in this method, other items are often recommended from the same category as the category of an item browsed by a user, but items have viewpoints.

Many shops participate in online shopping sites. The sites have not only their own category with all items but also many specific category structures in the participating shops. These categories represent some of the intended item uses. In this work, we recommend participating shops and items in shops based on viewpoints for browsed items, considering these shops' viewpoint specialties. A user has a purpose in browsing items. Using specific category structures in participating shops, we assume intended browsed item uses. For example, we recommend specialty shops having the categories "Outdoors" and "Emergency Supplies" for flashlights.

II. Our Approach

A. A Recommender System for Specialty Shops

In this work, we use specific category structures in participating shops to infer viewpoints among browsed items. Specifically, we use parent categories having child categories with browsed items in participating shops, because these categories might represent intended uses of items. For example, when the browsed items are flashlights and retort-packed food and there are parent categories "Outdoor Gear" or "Emergency Supplies" having these items in participating shops, we infer that the viewpoints among these browsed items are outdoor leisure and disaster preparedness. Then, we analyze category structures in participating shops, in order to determine specialty shops based on these viewpoints and recommend these specialty shops. Figure 1 shows an example of a recommendation. A user has browsed "Flashlight" and "Retort-packed food". We present parent categories "Outdoor Gear" and "Emergency Supplies" as viewpoints for these items. Then, we also present child categories such as "Outdoor Gear $>$ Camping" or "Emergency Supplies $>$ Foods" under the parent categories. Choosing a category, a user can browse recommended items suitable for the user's purposes.

B. Related Work

Kato et al. [1] and Duc et al. [2] proposed methods for searching objects based on the relational similarity between words from their emergence distribution on the Web. These methods are similar to our work in that they use relations among objects, but our method differs in extracting relations among objects based on online shops' category structures.

Seki et al. [3] proposed a method for recommending suitable items for a user's context. It is similar to our work in recommending suitability for a user's viewpoint, but our method differs in considering specialties to recommending shops based on a user's viewpoint.

Rakuten ichiba [4] shows a participating shop ranking by according to opening day, number of items, and number of reviews. However, that site does not consider shop specialties.

III. A Method for Determining Degrees of A Shop's Specialty Based on a Viewpoint

In this section, we explain methods for calculating degrees of a shop's specialty in regard to viewpoints among browsed items. We define a shop's specialty as the result of a calculation using an item classification method, item selection, and the main target genre of items in the shop.

A. The Degree of a Shop's Specialty Based on a Classification Method of Items

We consider an item classification method to determine the degree of shop specialty. Shops having detailed categories for classifying items and using the categories properly are specialty shops. The degree based on the classification method $C\_Score(X, i)$ is calculated using the following expression:

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[1]http://www.rakuten.co.jp/

[2]http://www.amazon.com/

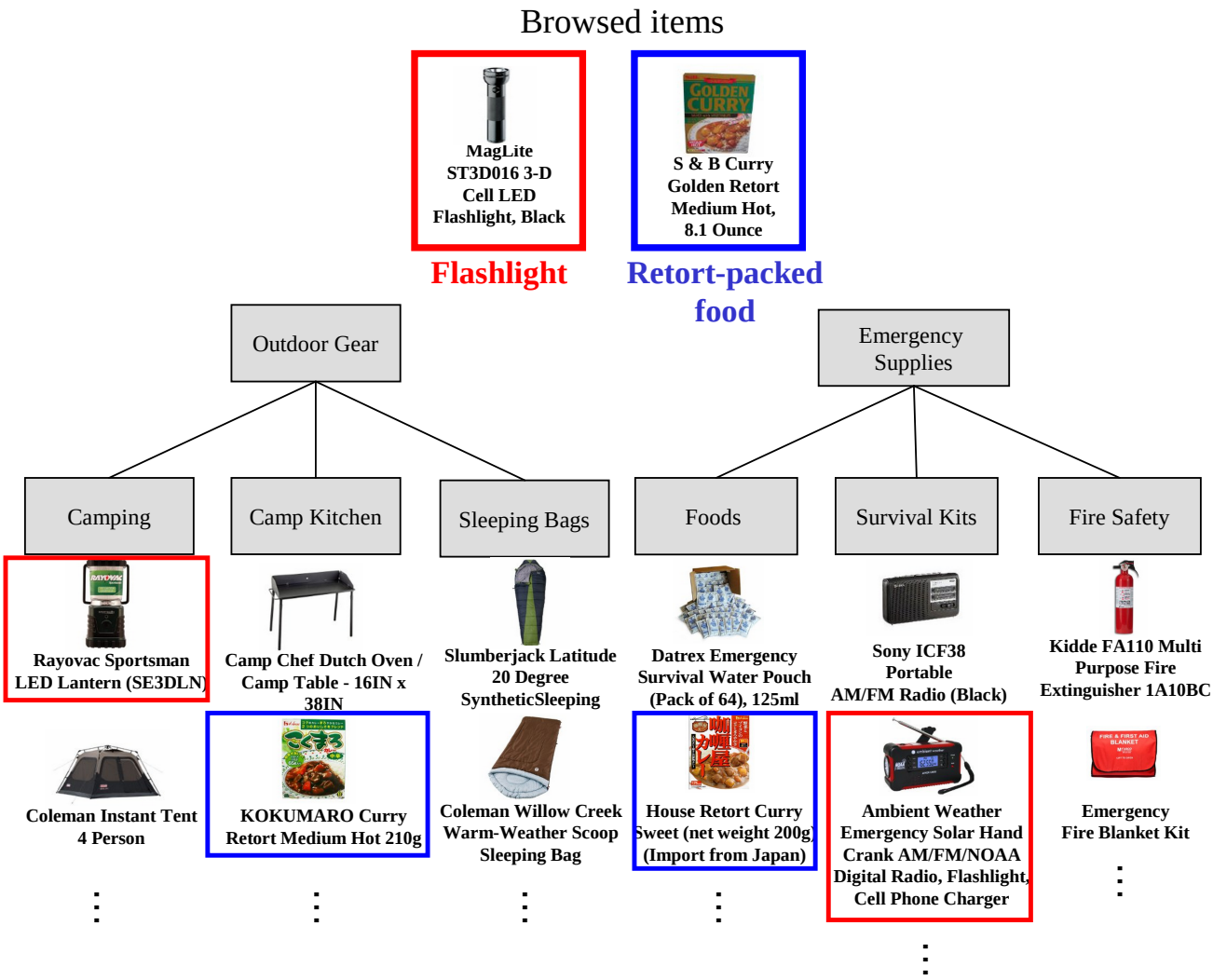

Fig. 1. An E-commerce Recommender System based on Degree of Specialties in Online Shops

$$C\_Score(X,i) = \alpha \times Detail(X,i) + (1-\alpha) \times Uniformity(X,i) \quad (1)$$

where the function $Detail$ returns a degree of detail of a category structure in a shop i based on browsed items X, and the function $Uniformity$ returns a degree of detail of using the category structure properly. $Detail$ and $Uniformity$ of shop i based on items X are calculated as follows:

$$Detail(X,i) = W(X,i) \times D(X,i) \quad (2)$$

where W and D are, respectively, the number of the end categories of shop i's category structure and the number of layers in the category structure of a parent category with items X.

$$Uniformity(X,i) = \frac{1}{1+\sigma} \quad (3)$$

$$\sigma = \sqrt{\frac{1}{p}\Sigma_{l=1}^{p}\left(C(X,i,l) - \frac{\Sigma_{l=1}^{p} C(X,i,l)}{p}\right)^2} \quad (4)$$

where C is the number of items belonging to category l. This category l is one of the end categories of shop i's parent category structure with items X. σ is a standard deviation of the number of items belonging to end categories of shop i's parent category structure with items X. Intuitively, $Uniformity$ means the degree of uniformity in quantities of items belonging to end categories. Figure 2 shows examples of a shop's degree of specialty based on the item classification method. Shop A's category structure of "C[1]" with width six and depth three is more detailed than shop B's category structure of "C[1]" with width four and depth three. Shop A has more uniformity in quantities of items belonging to categories than shop C.

B. The Degree of a Shop's Specialty Based on Selection of Items

We consider selection of items to determine a degree of shop specialty. Shops with a large range of items are specialty shops. The degree based on selection of items $S\_Score(X,i)$ is calculated using the following expression:

$$S\_Score(X,i) =$$

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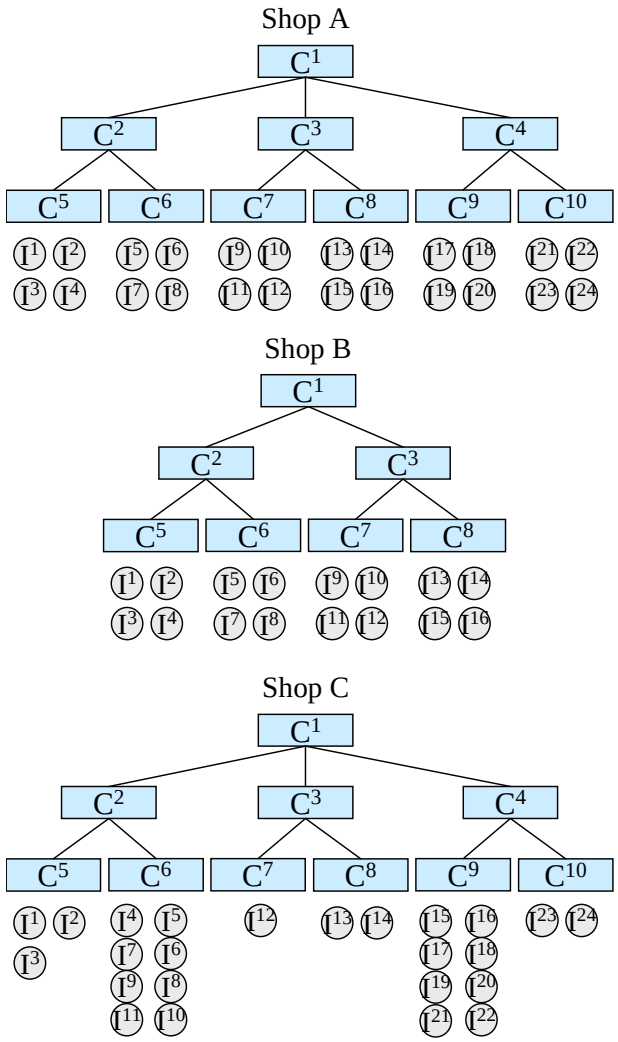

Fig. 2. Classification by category structures based on viewpoints

$$\beta \times \left(Cover\,(X,i) - \frac{\Sigma_{n=1}^{m} Cover\,(X,n)}{m} \right)^2 + \gamma \times \left(Rare\,(X,i) - \frac{\Sigma_{n=1}^{m} Rare\,(X,n)}{m} \right)^2 \quad (5)$$

$$\beta = \begin{cases} 1 & \left(Cover\,(X,i) - \frac{\Sigma_{n=1}^{m} Cover(X,i)}{m} \geq 0 \right) \\ -1 & (other) \end{cases} \quad (6)$$

$$\gamma = \begin{cases} 1 & \left(Rare\,(X,i) - \frac{\Sigma_{n=1}^{m} Rare(X,i)}{m} \geq 0 \right) \\ -1 & (other) \end{cases} \quad (7)$$

where the function $Cover$ returns a degree of the quantities of all items, and the function $Rare$ returns a degree of selection of hard-to-find items of a point of view based on browsed items X in shop i. $Cover$ and $Rare$ of shop i based on items X is calculated as follows:

$$Cover(X,i) = \frac{\mid G(X,i) \mid}{\mid \bigcup_{n=1}^{m} G(X,n) \mid} \quad (8)$$

where G is a set of items of a viewpoints based on items X in shop i. The function $Cover$ returns the ratio of the number of G of a viewpoint based on items$X$ in shop i to the number of G of the viewpoint based on items$X$ in all shops. Intuitively, $Cover$ means the degree of quantities of items of a viewpoint based on browsed items X.

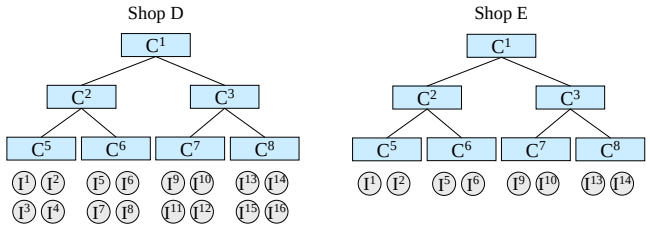

Fig. 3. Quantity of items based on a viewpoint

Figure 3 shows examples of shops' degree of specialty based on $Cover$. Because Shop D's "C^1" category has more items than Shop E's "C^1" category, Shop D is more specialized for a viewpoint as "C^1" based on $Cover$ than Shop E.

$$Rare(X,i) = \Sigma_{o \in G(X,i)} e^{\log(\frac{|S(X,o)|}{m}) - 1} \quad (9)$$

where G is a set of items of a viewpoint based on items X in shop i. S is a set of shops having items X and item o the same as one of $G(X,i)$. Using S , we determine an item o 's rarity. Figure 4 shows examples of items' rarity. Because items I^1, I^2, I^3 and I^4 belong to Shop A, Shop B, and Shop C, they are not rare. However, item I^5 is rare, because it belongs only to Shop A. Intuitively, $Rare$ means the degree of selection of hard-to-find items that most shops do not have.

C. The Degree of a Shop's Specialty Based on the Main Target Genre

We consider that all of a shop's items match a viewpoint of browsed items. Shops having only items of a viewpoint of browsed items are specialty shops. The degree based on the main target genre of a shop is calculated using the following expression:

$$Precision(X,i) = \frac{\log \mid G(X,i) \mid}{\log \mid N(i) \mid} \quad (10)$$

where G is a set of items of a viewpoint based on items X in shop i. N is a set of items in shop i. The function $Precision$ returns the ratio of the number of G to the number of N.

IV. An Example of Calculating Shops' Specialties Based on a Viewpoint

We calculated the degree of specialty of shops in rakuten.co.jp based on the viewpoint "Emergency Supplies." We collected 17 shops (see TABLE I) having the category "Emergency Supplies" using the Rakuten Ichiba API. In the experiment, we calculated the degrees of these shops' specialty based on the viewpoint. We present the calculation results in TABLE II, showing categories based on viewpoint "Emergency Supplies," $Detail$, $Uniformity$, $Cover$, $Rare$, $Precision$, $C\_Score(X,i)$ and $S\_Score(X,i)$.

TABLE II shows that Shop anzenlif and Shop bousaikan have high degrees of specialty based on the classification

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method ($C\_Score(X,i)$). Because these shops have a relatively detailed category structure of "Emergency Supplies" and deal effectively with it, these shops are specialty shops in terms of the classification method. Therefore, it is believed that the $C\_Score(X,i)$ values of these shops are reasonable. In contrast, Shop maxshare and Shop royal3000 have a low degree of $C\_Score(X,i)$. Shop maxshare's category structure and Shop royal3000's category structure of "Emergency Supplies" are each composed of only one category, so these shops are not specialty shops in terms of the classification method. Shop bousaianshin has the most detailed category structure. However, this shop could not deal effectively with the category structure. Therefore, this shop is not a specialty shop in terms of the classification method and its low degree of $C\_Score(X,i)$ is reasonable.

Shop bousaianshin has a high degree based on selection of goods ($S\_Score(X,i)$), and its $Cover$ is very high. Thus, this shop has enormously many items based on the viewpoint "Emergency Supplies." In addition, selection of hard-to-find items ($Rare$) in this shop is very high. Similarly, because Shop bousaiss, Shop ganpon and Shop anmakuya have relatively many items based on the viewpoint, these shops also have high degrees of $Cover$ and $Rare$. It may be suspected that $Rare$ tends to be high if $Cover$ is high. However, this is an undesirable outcome. If a shop has many items, the degree of $Rare$ must be low when the shop does not have many hard-to-find items. We suspect that the cause of the problem is the number of shops used in this experiment. An Item's rarity is determined by the number of shops that have it. Because the number of shops is low in this experiment, the maximal value of items' rarity is low. Therefore, we need to modify the method for calculating $Rare$.

Shops having a high degree of $Precision$ are Shop anmakuya, Shop anzenlife, Shop be-kan, Shop bousaianshin, Shop bousaiss, Shop ganpon, Shop saibou, Shop bouhanbousai and Shop bousai-web. All items in these shops are of the viewpoint "Emergency supplies," so they are shops as a whole targeting emergency supplies. Therefore, we believe that the $Precision$ values of these shops are reasonable.

V. Conclusion

In this paper, we proposed a method for determining degree of shops ' specialty based on a viewpoint extracted by using category structures of online shops to build a recommender system for specialty shops based on viewpoints of items browsed by users. In addition, to verify the our method, we calculated the degree of specialty of shops in rakuten.co.jp based on the viewpoint "Emergency Supplies."

As future work, we intend to repeat the experiment using many shops in order to verify and modify the method for calculating $Rare$. Then, we need to evaluate the usability of the recommendations of specialty shops determined by our method to confirm that it can match user viewpoints.

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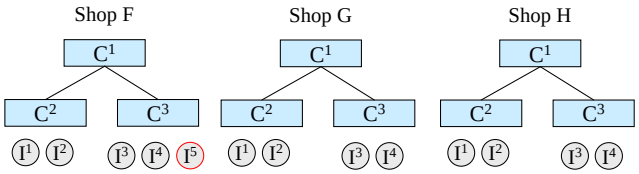

Fig. 4. Rarity of items

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[4] Rakuten ichiba, http://www.rakuten.co.jp/.

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TABLE I
EXPERIMENTAL DATA: SHOP DATA

Shop's name	The number of items	Depth of category structure	Width of category structure
anmakuya	1149	5	108
anzenlife	405	5	146
be-kan	714	5	173
bousaianshin	13324	5	194
bousaiss	441	3	48
ganpon	511	5	75
saibou	487	4	77
bousaikan	1190	6	105
wowsystem	914	5	49
bouhanbousai	14	2	8
bousai-web	237	3	53
gekiyasukaguya	6805	6	334
maxshare	608	5	65
onestep	33204	8	1962
royal3000	1527	5	106
smile-hg	4648	6	379
murauchi-denki	236906	7	2707

TABLE II
EXPERIMENTAL RESULTS: DEGREE OF SPECIALTY

Shop's name	Target Category as "emergency supplies"	$Detail$	$Uniformity$	$Cover$	$Rare$	$Precision$	C_Score	S_Score
anmakuya	Root category	0.556	0.033	0.015	0.026	1.000	0.005	-0.004
anzenlife	Root category	0.752	0.092	0.011	0.013	1.000	0.017	-0.006
be-kan	Root category	0.892	0.035	0.010	0.017	1.000	0.008	-0.005
bousaianshin	Root category	1.000	0.006	0.811	1.000	1.000	0.002	1.431
bousaiss	Root category	0.148	0.059	0.027	0.028	1.000	0.002	-0.003
ganpon	Root category	0.386	0.071	0.021	0.028	1.000	0.007	-0.003
saibou	Root category	0.317	0.109	0.012	0.013	1.000	0.009	-0.005
bousaikan	Root category > Emergency supplies	0.360	0.206	0.013	0.016	0.785	0.019	-0.005
wowsystem	Root category > Emergency supplies	0.013	0.070	0.007	0.012	0.687	0.000	-0.006
bouhanbousai	Root category	0.015	0.462	0.001	0.000	1.000	0.002	-0.008
bousai-web	Root category	0.163	0.034	0.013	0.016	1.000	0.001	-0.005
gekiyasukaguya	Root category > The sale > Special topic > emergency supplies	0.015	0.163	0.003	0.004	0.412	0.001	-0.007
maxshare	Root category > Emergency supplies	0.000	1.000	0.002	0.002	0.489	0.000	-0.008
onestep	Root category > Home, Garden & Tools > Emergency supplies	0.007	0.051	0.006	0.006	0.423	0.000	-0.007
royal3000	Root category > Home, Garden & Tools > Emergency supplies	0.000	1.000	0.001	0.001	0.394	0.000	-0.008
smile-hg	Root category > Security gear & Emergency supplies > Emergency supplies	0.036	0.095	0.009	0.015	0.579	0.001	-0.005
murauchi-denki	Root category Tools & Home Improvement > Emergency supplies	0.009	0.066	0.008	0.010	0.389	0.000	-0.006

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