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Book Recommendation based on Library Loan Records and Bibliographic Information

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Abstract

In order to show the effectiveness of using (a) library loan records and (b) information about book contents as a basis for book recommendations, we entered various data into a support vector machine (SVM), used it to recommend books to subjects, and asked them for evaluations of the recommendations that were given. The data that we used were (1) confidence and support with an association rule that was based on the loan records, (2) similarities between book titles, (3) matches/mismatches between the Nippon Decimal Classification (NDC) categories of the books, and (4) similarities between the outlines of the books in the *BOOK Database*. The subjects were 32 students who belonged to T University. The books that we recommended and the loan records that we used were obtained from the T University Library. The results showed that the combinations of (1), (2), (3) and (1), (2) were rated more favorably by the subjects than the other combinations. However, the books that were recommended by Amazon were rated even more favorably by the subjects. This is a topic for further research.

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Keywords: Book Recommendation; Recommender System; Library Loan Records; Support Vector Machine; SVM

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1. Introduction

The effective use of library loan records for generating recommendations has been actively discussed among librarians and library and information science researchers. One method is to recommend books to users based on loan records. Some studies have proposed approaches for implementing this method. However, most of these methods use only the information from loan records. Book titles and the Nippon Decimal Classification (NDC) categories that have been assigned to the books have not been used. We contend that book titles, NDC categories, and the outlines of books from the *BOOK Database* are important additional clues that can be used for the purpose of formulating effective book recommendations and that the optimum combination and weighting of these additional clues can be determined through machine learning. In particular, the similarities between titles, matches on the NDC category, similarities between the outlines in the *BOOK Database*, and association rules that are based on the loan records can be used as "features" of learning data. Support vector machines (SVM) can use this data to determine the weights of the features, perform automatic classifications, and generate recommendations.

In our experiment, subjects were asked to provide the name of "one book that currently interests the subject" and a recommendation was made by the SVM based on the following information: (1) the confidence and support from an association rule, (2) similarities between titles, (3) matches/mismatches between NDC categories, and (4) similarities between the outlines in the *BOOK Database*. Tsuji et al. (2011) (2012) found that Amazon's book recommendation system had better results than a recommendation system that was based only on an association rule that used library loan records. In our experiment, book recommendations were conducted and comparisons with Amazon were included.

In this study, the books that we recommended were books from the T University Library and the library loan records were also from the T University Library. We recommended books to test subjects non-graphically (i.e., by showing only the bibliographic data, such as the title, author, publisher, and publication year of the book).

2. Related Studies

There have only been a few studies of book recommendations based on library loan records. Harada (2009) and Harada & Masuda (2010) used collaborative filtering. Tsuji et al. (2011) (2012) used 1,854,345 loan records from 39,442 users of the T University Library and recommended books to 33 undergraduate and graduate students based on (1) the collaborative filtering method that was proposed by Harada & Masuda (2010), (2) an association rule, and (3) Amazon. They found that the evaluations of these methods were ranked from best to worst as Amazon, association rules, and then collaborative filtering.

Whitney & Schiff (2006) proposed a recommendation method that used a weighted graph model that is similar to the association rule method. Chen & Chen (2007), Luo et al. (2009), and Shirgaonkar et al. (2010) proposed various recommendation methods, but did not conduct experiments in order to evaluate their effectiveness.

3. Data

3.1. Library Loan Records and Bibliographic Data of T University Library

We obtained 2,324,418 loan records from the T University library. The checkout dates ranged from January 2, 2006 to March 31, 2012. Of these records, 999,630 were for books that were checked out by undergraduate students. 1,294,012 books were checked out by graduate students and faculty members. 30,776 books were checked by other types of patrons. We used 2,293,642 loan records from undergraduate students, graduate students, and faculty members for this study. The number of types of books that were borrowed was 477,668 and the number of users was 44,571. The number of baskets (i.e., sets of books that were borrowed together) was 821,771.

For recommendation, we chose books to which the NDC categories were assigned in the T University Library. The number of these books was 643,676. NDC categories have not been assigned to many of the books in the T University Library collection that are written in English or other non-Japanese languages. As a result, the number 643,676 is much smaller than the total number of books that the T University Library holds.

3.2. BOOK Database

The *BOOK Database* is a database that contains outlines and bibliographic information for books that have been published recently in Japan. We used information for books that were published between 2005 and 2011. The numbers of books with outlines were 44,143 (2005 editions), 45,327, 48,241, 48,214, 48,459, 45,654, and 44,652 (2011 editions). Outlines have been assigned to approximately 75% of the books.

3.3. Subjects

Thirty-two students that were majoring in library and information science at T University participated as subjects in our experiment. They included 13 graduate students, 12 fourth-year undergraduate students, and 7 second-year undergraduate students. For convenience's sake, we will call these three groups "groups whose grades are different," although graduate students and undergraduate students are not regarded as being different "grades" according to the normal definition.

3.4. One Book that the Subject Would Like to Borrow at Present

Subjects were asked to provide the title (and other bibliographic information, if necessary) of one "book that I would like to borrow from T University library at present for research or study purposes" (henceforth, "a book that currently interests the subject"). This information was used to generate recommendations based on an association rule (confidence and support), similarities between the titles, similarities between the *BOOK Database* outlines, matches between the NDC categories, and the Amazon recommendation system.

3.5. Learning Data

Two types of learning data were prepared for the SVM as follows.

(1) In 2011, Tsuji et al. (2011) asked 33 subjects to provide the name of one book that currently interested them. Based on the books, they recommended 460 books using an association rule and they asked the subjects to evaluate their degree of interest in the book that was recommended using the same criteria that are used in this study (to be described later). In this way, they obtained 460 pairs of books. In this study, the pairs where the recommended book was evaluated as "2: very interested" and "0: not interested" were considered as positive examples and negative examples, respectively, and were used as the first set of learning data. The total number of pairs in the learning set was 186 and the numbers of pairs of positive examples and negative examples were 59 and 127, respectively.

(2) The second set of learning data was as follows. First of all, we divided the 32 subjects that we mentioned in Section 3.3 into two groups, S and T. We presented the following sets of books to each member of group S and asked for evaluations: (a) six books with the highest probability of belonging to positive examples (described later) based on the output from an SVM that was using the learning data described above, (b) six books with the highest similarities based on titles, (c) six books with the highest confidence levels based on the association rule, (d) six books with the highest similarities based on the outlines in the *BOOK Database*, and (e) six books that were recommended by Amazon. By the same way as (1), we obtained 172 pairs of learning data (i.e., positive examples that the subjects evaluated as "2: very interested" and negative examples that they evaluated as "0: not interested").

These results were combined with the first set of pairs to give a total 358 pairs that were used for SVM learning. The numbers of pairs of positive and negative examples were 111 and 247, respectively.

The following section discusses the evaluations from the T group of book recommendations that were produced by the SVM. In addition, evaluation results obtained from 32 subjects are also discussed in regards to recommendation that does not require learning like (b), (c), (d), and (e) above. This is the reason that the number of samples is different depending on methods in the following Tables. Results based on the first pairs for learning are also discussed at the end.

4. Recommendation Method

4.1. Recommendations based on Similarities between the Titles and the Outlines in the BOOK Database

Books whose titles are similar to those of the "books that currently interest the subjects" may be favorably evaluated by the subjects. In order to recommend such books, we calculated the similarities between titles (and the outlines) as follows. (1) Titles (or outlines) of all the books held in T University Library as well as "books that currently interest the subjects" are divided into words using the Japanese morphological analyzer MeCab ver. 0.994. (2) Single nouns and two noun sequences were extracted from the strings of words. (3) The vectors consisting of the TFIDF (term frequency-inverse document frequency) from these single nouns and two noun sequences were created for each book. The TFIDF of a single noun *S* concerning book *A* is defined as the "frequency of *S* in the title (or outline) of book *A*" multiplied by "log (the number of all the books held in T University Library) / (the number of books whose titles (or outline) contain *S* in the title)". (4) The similarity between the titles (or outlines) of two books is defined as the cosine measure of their corresponding vectors. (5) The six books with the highest cosine measures (out of all the books held in T University Library) when compared with "books that currently interest the subject" were recommended to the subject. (6) Similarities between titles (or outlines) in the above were also adopted as the feature (information used for classification) for recommendations by the SVM, which we will mention later.

4.2. Recommendations based on an Association Rule

When a user borrows *n* books, X_i (i = 1, ..., n), at one time, we call the set $\{X_1, \ldots, X_n\}$ a "transaction". For instance, when a user borrows three books, A, B, and C, at one time, this transaction can be represented as {A, B, C}. From this transaction, we can extract a rule that "the user who borrows book A also borrows book B." If we represent this rule as A → B, where A is called the premise and B is called the conclusion, then we can also extract other rules, such as A → C, B → A, B → C, C → A, and C → B. Based on all of the transactions from all of the users, the association rule extracts the frequently observed, and, in this sense, useful and reliable rules.

The "confidence" and "support" are the most widely used measures for usefulness and reliability of the rule X → Y, respectively. The level of confidence is defined as the ratio of "the number of transactions that contain X and Y" against "the number of transactions that contain X". The level of support is defined as the ratio of "the number of transactions that contain X and Y" against "the number of all transactions". We recommended six books to each subject based on the six rules with the highest confidence levels that have the "premise" X is "a book that currently interests the subject."

When recommending based only on an association rule, we did not consider the support for each rule. However, the recommendations based on both confidence and support might be more effective. Therefore, we used both of them as features for the SVM that will be discussed in the next section.

4.3. Recommendation by SVM Using Multiple Information

It might be effective to recommend books based on multiple sources of information combined with optimal parameters, rather than a single source of information (such as confidence by association rule). SVM is widely used machine learning method that can use multiple parameters. We obtained evaluation results from subjects for SVM learning (i.e., to determine optimal parameters for classifying books into those that should be recommended and those that should not be recommended), which will be described in Section5. We used the following four sources of information for SVM features:

(a) Confidence and support from the association rule based on the library loan records
(b) Similarities between book titles
(c) Matches/mismatches on NDC category (if all of their classes, divisions, and sections matched, then 1; else 0)
(d) Similarities between the outlines of the books in the BOOKDB

Henceforth, we will refer to (a), (b), (c), and (d) as Loan Record, Title, NDC, and BOOKDB, respectively. We examined the effectiveness of the following combinations of features:

(1) Title + Loan Record
(2) NDC + Title
(3) NDC + Title + Loan Record
(4) NDC + Title + Loan Record +BOOKDB

We used LIBSVM ver. 3.12 and adopted the L1 soft margin SVM "C-Support Vector Classification" and the RBF (Radial Basis Function) kernel. We used the easy.py script to obtain optimal parameters C (margin parameter which determines the generalization ability) and γ (parameter which determines the influence a single training example has). We also used the –b option to display the probability that a book belonged to the class of "books that should be recommended." We selected six books whose probabilities were the highest based on the combinations (1)–(4) that are described above and recommended these books to the subjects. Therefore, a total of 24 books were recommended to each of the subjects by the SVM.

4.4. Amazon

We entered the "books that currently interest the subjects" as input into the Amazon recommendation system and obtained a list of the six books that were recommended by Amazon based on "the customer who purchased this book also purchased these books." From these books, we extracted the books that were in the collection at the T University Library and recommended these books to the subjects.

5. Evaluation Method

The bibliographic data from the books that were recommended based on the above-mentioned methods were shown to the subjects. The subjects were then asked to describe their level of interest in each book using the following five-point scale that is similar to the scale that was used by Tsuji et al. (2011) (2012): "2: Very interested", "1: Interested", "0: Not interested", "x: Have no idea", and "A: Have already bought or read".

6. Results

6.1. Overall Results

Table 1 displays the evaluation results for recommendations based on: (1) SVM with combination of various features, (2) similarities of titles only, (3) confidence based on the association rule only, (4) similarities of the outlines in the BOOKDB only, and (5) Amazon as described above. We can see in Table 1 that 96 books were recommended using "NDC + Title + Loan Record" and that out of these books, 14 books were evaluated as "2: Very Interested" by the subject, thereby accounting for 14.6% (= 14 / 96 * 100) of the books that were recommended. On the other hand, 192 books were recommended using similarities of titles only and out of these books, 65 books were evaluated as "1: would like to read", thereby accounting for 33.9% (= 65 / 192 * 100).

If "A: Already Bought or Read", "2: Very Interested", and "1: Interested" are considered to be "positive evaluations" as they were in Tsuji et al. (2011) (2012), then according to Table 1, the method (not including Amazon) with the highest proportion of positive evaluations was "NDC + Title + Loan Record" with a result of 71.9% (= 6.3 + 14.6 + 51.0). The second highest is "BOOKDB + NDC + Title + Loan Record" with a result of 65.7% (= 6.3 + 12.5 + 46.9). This was followed by "Title + Loan Record" with a result of 63.6% (= 3.1+ 24.0 + 36.5). These values are all higher than the 53.1% (= 3.9 + 17.2 + 32.0) that was obtained for the case that only used the loan records (i.e., only confidence with the association rule was used), the 54.2% (= 2.6 + 17.7 + 33.9) that was obtained for the case using only the similarities of the titles, and the 62.1% (= 0.0 + 13.6 + 48.5) that was obtained for the case using only the similarities of the outlines in the *BOOK Database*. Therefore, it has been shown that recommendations based on SVM using multiple sources of information lead to better results than recommendations that are based on methods that use a single source of information, such as titles or loan records. On the other hand, recommendations from methods that did not use loan records (such as "NDC + Title") were evaluated less favorably than recommendations from methods that used loan records (such as "NDC + Title + Loan

Record"). Therefore, book recommendations aided by the loan records were more effective than recommendations based only on titles or NDC categories.

In regards to the proportion of books that were evaluated as "2: Very Interested" (not including Amazon), "Title + Loan Record" had the highest proportion at 24.0%, followed by "Title" with 17.7%, and "Loan Record" with 17.2%. It should be noted that none of these include the NDC categories. This issue will be explained later.

Finally, none of the methods that were proposed in this study were as good as the Amazon method in regards to both "2: Very Interested" and positive evaluations as described above. This issue will be researched in the future.

6.2. Results by Grade

The results were compiled by dividing the subjects into graduate students, fourth-year undergraduate students, and second-year undergraduate students as shown in Tables 2, 3, and 4. According to these Tables, for fourth-year and second-year undergraduate students, the proportion of positive evaluations was the highest for "NDC + Title + Loan Record" at 75.0% (= 8.3 + 13.9 + 52.8) and 77.8% (= 0.0 + 27.8 + 50.0), respectively (excluding Amazon). However, for graduate students, "NDC + Title + Loan Record" was in second place with a proportion of positive evaluations of 66.6% (= 7.1 + 9.5 + 50.0) and "Title + Loan Record" was in first place with 73.8% (= 7.1 + 16.7 + 50.0). When the proportions of positive evaluations in the section above are compared, it is in the order of graduate students (66.6%) ＜ fourth-year undergraduate students (75.0%) ＜ second-year undergraduate students (77.8%). Thus, recommendations that use NDC are better for undergraduate students. However, it may be better if NDC is not used for recommendations to graduate students. This issue will be discussed later.

6.3. Results by Volume of Learning Data

As described in Section 3.5, two kinds of learning data were used in this study. One consisted of 186 pairs and the other consisted of 358 pairs. Up to this point we have shown the results when the latter was used. Results from the learning data with 186 pairs are shown as in Table 5. We can see from Table 5 that percentage of positive evaluations for "NDC + Title + Loan Record" was at 54.1% (= 2.6 + 18.2 + 33.3) when the learning data set is small (186 pairs). The ratio is significantly smaller than that (71.9%) obtained when the learning data was large (358 pairs). Since the difference above was observed when the size of the learning data set was roughly doubled, it is possible that the performance of the method in this study can be improved in the future by creating and using a larger learning data set.

7. Discussions

The results from this study indicated that the proportion of positive evaluations is the highest for "NDC + Title + Loan Record" and that the proportion of "2: Very interested" is the highest for "Title + Loan record." In fact, "NDC + Title + Loan Record" only recommended books that had the same NDC as the "one book that currently interests the subject," and "Title + Loan Record" recommended different books as well.

The shelves in a library can serve as locations that contain book recommendations. It is likely that users that are interested in a concrete research theme and frequently borrow books at a library (i.e., users who have their favorite shelves), have a certain understanding of the books that are related to their interest through their experiences at the relevant library shelves. Therefore, it is possible that these users were already aware of many of the books that have the same NDC (i.e., book from their favorite shelves) as the one book that they are currently interested in. The validity of this assumption seems to be supported by the facts that (1) the proportion of positive evaluations for "NDC + Title + Loan Record" was in the order of second-year undergraduate students > fourth-year undergraduate students > graduate students, and (2) for graduate students, the proportion of positive evaluations was higher for "Title + Loan Record", where books with different NDC categories were also recommended, than it was for "NDC + Title + Loan Record", where only books with the same NDC were recommended. Therefore, it may be effective to switch between these two methods depending on the user. This could be accomplished by determining whether or not the student has favorite shelves, for instance, based on the year of the student or the number of books that the student has borrowed in the past.

Finally, we used a simple cosine measure for determining the similarities between titles. However, the value of this measure tends to be higher when the titles are short. Many recent books have long titles, and older books tend to have simpler and shorter titles. Therefore, recommendations based on similarities between titles tended to recommend very old books. The year of publication could be incorporated into the SVM as a feature in the future.

8. Conclusions

We proposed a method for utilizing multiple sources of information with an SVM and showed its effectiveness. While the information that we used was limited to library loan records, book titles, NDC categories, and outlines from the *BOOK Database*, other information could be easily added or incorporated. There are many possibilities for expanding our method.

We showed that methods that use multiples sources of information with the SVM such as "NDC + Title + Loan Record" and "Title + Loan Record" perform better than other methods that rely only on loan records or similarities between titles and also better than methods than rely on other combinations of information. Therefore, library loan records should be considered as a possible source of information when creating book recommendations even though there is a risk of privacy leakage associated with using them for this purpose. It was also indicated in this study that relatively high evaluations could be obtained by recommending books with different NDC categories to students at the fourth-year undergraduate and graduate levels. Therefore, it is advisable to consider switching recommendation methods depending on the target users.

The first task for the future is to determine how much the performance of the methods in this study will improve when the size of the learning data set increases. The possibility of incorporating information specific to the university students into the book recommendations should also be pursued. This could include the courses and related reference books for each student. In addition, subjects were only asked to indicate the "degree of interest" in this study, without any consideration for what they felt when they answered that they were "interested" in a particular book. For instance, a subject might have replied that they were "interested" when a book was recommended from an unexpected new field, or because they knew about the book, but had not read it yet. We hope to typify interests in the future in order to develop methods for book recommendations that are suitable for each interest. In conclusion, this study only covered the SVM as a representative method for automatic classification, while random forest methods and Naive Bayes classifier methods are also available for automatic classification. It seems likely that these methods will not significantly surpass SVM's performance, but comparison and verification will be necessary in the future.

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Table 1. Overall Results

	A: Already Bought or Read	2: Very Interested	1: Interested	0: Not Interested	Total
Loan Record	5 (3.9)	22 (17.2)	41 (32.0)	60 (46.9)	128
Title	5 (2.6)	34 (17.7)	65 (33.9)	88 (45.8)	192
NDC + Title	3 (3.1)	16 (16.7)	41 (42.7)	36 (37.5)	96
Title + Loan Record	3 (3.1)	23 (24.0)	35 (36.5)	35 (36.5)	96
NDC + Title + Loan Record	6 (6.3)	14 (14.6)	49 (51.0)	27 (28.1)	96
BOOKDB + NDC + Title + Loan Record	6 (6.3)	12 (12.5)	45 (46.9)	33 (34.4)	96
BOOKDB	0 (0.0)	9 (13.6)	32 (48.5)	25 (37.9)	66
Amazon	16 (23.9)	22 (32.8)	27 (40.3)	2 (3.0)	67

Table 2. Results for Graduate Students

	A: Already Bought or Read	2: Very Interested	1: Interested	0: Not Interested	Total
Loan Record	5 (8.9)	6 (10.7)	15 (26.8)	30 (53.6)	56
Title	4 (5.1)	10 (12.8)	25 (32.1)	39 (50.0)	78
NDC + Title	3 (7.1)	4 (9.5)	15 (35.7)	20 (47.6)	42
Title + Loan Record	3 (7.1)	7 (16.7)	21 (50.0)	11 (26.2)	42
NDC + Title + Loan Record	3 (7.1)	4 (9.5)	21 (50.0)	14 (33.3)	42
BOOKDB + NDC + Title + Loan Record	3 (7.1)	3 (7.1)	20 (47.6)	16 (38.1)	42
BOOKDB	0 (0.0)	2 (8.3)	11 (45.8)	11 (45.8)	24
Amazon	13 (34.2)	13 (34.2)	11 (28.9)	1 (2.6)	38

Table 3. Results for Fourth-Year Undergraduate Students

	A: Already Bought or Read	2: Very Interested	1: Interested	0: Not Interested	Total
Loan Record	0 (0.0)	7 (15.2)	17 (37.0)	22 (47.8)	46
Title	0 (0.0)	15 (20.8)	28 (38.9)	29 (40.3)	72
NDC + Title	0 (0.0)	7 (19.4)	17 (47.2)	12 (33.3)	36
Title + Loan Record	0 (0.0)	11 (30.6)	12 (33.3)	13 (36.1)	36
NDC + Title + Loan Record	3 (8.3)	5 (13.9)	19 (52.8)	9 (25.0)	36
BOOKDB + NDC + Title + Loan Record	3 (8.3)	4 (11.1)	17 (47.2)	12 (33.3)	36
BOOKDB	0 (0.0)	4 (13.3)	15 (50.0)	11 (36.7)	30
Amazon	2 (10.5)	7 (36.8)	10 (52.6)	0 (0.0)	19

Table 4. Results for Second-Year Undergraduate Students

	A: Already Bought or Read	2: Very Interested	1: Interested	0: Not Interested	Total
Loan Record	0 (0.0)	9 (34.6)	9 (34.6)	8 (30.8)	26
Title	1 (2.4)	9 (21.4)	12 (28.6)	20 (47.6)	42
NDC + Title	0 (0.0)	5 (27.8)	9 (50.0)	4 (22.2)	18
Title + Loan Record	0 (0.0)	5 (27.8)	2 (11.1)	11 (61.1)	18
NDC + Title + Loan Record	0 (0.0)	5 (27.8)	9 (50.0)	4 (22.2)	18
BOOKDB + NDC + Title + Loan Record	0 (0.0)	5 (27.8)	8 (44.4)	5 (27.8)	18
BOOKDB	0 (0.0)	3 (25.0)	6 (50.0)	3 (25.0)	12
Amazon	1 (10.0)	2 (20.0)	6 (60.0)	1 (10.0)	10

Table 5. Results Based on Volume of Learning Data

		A: Already Bought or Read	2: Very Interested	1: Interested	0: Not Interested	Total
Learning Data – Small	Title + Loan Record	0 (0.0)	23 (12.0)	56 (29.2)	113 (58.9)	192
	NDC + Title + Loan Record	5 (2.6)	35 (18.2)	64 (33.3)	88 (45.8)	192
	BOOKDB + NDC + Title + Loan Record	4 (2.1)	37 (19.3)	66 (34.4)	85 (44.3)	192
Learning Data – Large	Title + Loan Record	3 (3.1)	23 (24.0)	35 (36.5)	35 (36.5)	96
	NDC + Title + Loan Record	6 (6.3)	14 (14.6)	49 (51.0)	27 (28.1)	96
	BOOKDB + NDC + Title + Loan Record	6 (6.3)	12 (12.5)	45 (46.9)	33 (34.4)	96