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A Novel Approach for Book Recommendation using Fuzzy based Aggregation

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Abstract

Objectives: To propose the top books for universities students by using the proposed fuzzy based approach, Ordered Ranked weighted Aggregation method. **Methods/Statistical Analysis:** The recommendations of books by different universities differ significantly. A staunch aggregation of the differently recommended books by the top ranked universities may lead to vigorous recommendation. We apply Positional Aggregation based Scoring technique, a rank aggregation method for partial list. We have suggested Ordered Ranked Weighted Aggregation (ORWA) operator, which assigns weights to the ranker. **Findings**: By using proposed technique, the recommendation of top ranked university is preferred over lower ranked universities. The philosophy of ORWA is the fact that the recommendation of a book by a top ranked university will eventually increase the importance of the recommended books. The top 20 books on "Artificial Intelligence" are recommended using PAS and ORWA based techniques. The recommendation would help the users in finding the books of their requirement. **Improvements**: The relative comparisons between both the discussed techniques PAS and ORWA are discussed and shown graphically. The results indicate a clear improvement of ORWA over PAS.

Keywords: Fuzzy Techniques, OWA, ORWA, Partial List, Recommendation Technique, Rank Aggregation

1. Introduction

The development of modern tools and technologies, and inclination of the new generation towards education has made the demand of Information exchange very high. The huge information available on a specific topic makes it tough for the people to grab the correct information. Books and research articles, whether online or offline, are the sources for obtaining information. So it is an important task to filter the sources for finding the desired books. There are millions of e-books available on the Internet and the numbers are increasing rapidly, this rapid increase has created a high demand of developing a recommendation technique to get exact and desired book.

The products are meant for the customers. Therefore customer's opinion is very important in product recommendation. The opinion or review from the customers work as a deciding factor in knowing the purchasing trends of the customers. The opinion mining comes into the picture to decide the purchasing trend of the customers and finding the features of the products when opinions about the products are available. Similarly, for books; we need the reviews of the readers or experts to know whether the books are worth buying or not?

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The reviews can be found at several merchandisers' sites like www.amazon.com or www.ebay.com, even there are few sites like www.epinions.com that contains the reviews of the different products. The technique that deals with the reviews or opinions is termed as opinion mining. For researchers, opinion mining is a very interesting topic in the field of data mining. For opinion mining we need to perform products feature analysis and products review analysis[1–3]. The product's features presented by speculators show only the superiority of their products. So, we cannot trust the speculators. And the reviews are prone to spamming[4]. Therefore we need to devise a technique that can handle the.

Generally recommender systems use customer's preferences and assume that several customers must have same taste and may like the similar products, however it is not the case always. If we are concerned about academic books, the selection is not the fun and must not be dependent upon student's choice, but it should be handled with utmost care and decided by the experts. Therefore specialized way of recommendation where authorities' recommendations are considered would be advisable and fruitful. Therefore it seems adequate while recommending books that one should ask the percept of experts at Universities instead of common people so that the above issues can be avoided.

In this paper, we intend to recommend top books for University's students in Indian scenario. That is why we have chosen top ranked universities in India and searched for their syllabus for the particular subject. Ordered Ranked Weighted Aggregation (ORWA), a fuzzy based averaging operator[5] is used in which a specific weight is assigned to ranking agents (rankers), in our case; the universities. The weight assignment method gives high weightage to the best ranked university and hence their rankings are evaluated with a high degree of preference than to those institutions that have lower ranking. The primary advantage of the adopted technique is that it includes the recommendation of high status top ranked universities as well as rank of the rankers i.e., universities, which are authorities for the academic program to recommend books for university students.

The main contributions in the paper are as follows:

We conferred a book recommendation method based on aggregation of expert's decision. Thus the problem of book recommendation is converted into decision making problem.

Positional Aggregation based Scoring Technique is implemented for recommendation process. To the best of our knowledge, we are the first to use this concept for book recommendation.

We propose an Ordered Ranked Weighted Aggregation (ORWA) operator which uses the rank of the rankers. The proposed technique may be very useful for decision making problems where rankers need to be taken into consideration.

The rest of the paper is organized as follows; in Section 2, we have discussed a brief background with some useful definitions and related work. Section 3 gives a comprehensive illustration for positional aggregation based scoring (PAS) technique and recommendation procedure for books based on PAS technique with suitable examples. In Section 4, we have described Ordered Weighted Aggregation (OWA) and discussed the origin of ORWA. The recommendation technique based on ORWA is also discussed in the section with diagram and examples. The experimental results and discussions are presented in Section 5. Finally we conclude in Section 6.

2. Background

In this section, we have given a concise background of the concepts involved, for a better understanding of the rank aggregation problems. Further a succinct discussion is reported for product recommendations in general, and book recommendation in particular.

The definitions of the relevant terms related to the proposed work are mentioned[6,7]

Definition 1 (List): "Given a universe U and $ş \subseteq U$, a list 'l' with respect to U is given as $l = [t_1, t_2, \ldots, t_{|ş|}]$, with each $t_i \in ş$, and $t_1 \succ t_2 \succ \cdots \succ t_{|ş|}$, where "$\succ$" is some ordering relation on ş. Also, for $i \in U \wedge i \in l$, let l(i) denote the position or rank of i. with a higher rank having a lower numbered position in the list. We may assign a unique identifier to each element in U, and thus, without loss of generality, we may get;

U = {1, 2, . . . , |U|}."

Definition 2 (Full list): "If a list l contains all the elements in U, then it is said to be a full list."

Example 1. A full list l given as [a3, a1, a4, a5, a2] has the ordering relation a3 ≻ a1 ≻ a4 ≻ a5 ≻ a2. The universe U may be taken as {1, 2, 3, 4, 5} with, say, a1 ≡ 1, a2 ≡ 2, a3 ≡ 3, a4 ≡ 4 and a5 ≡ 5. With such an assumption, we have l = [3, 1, 4, 5, 2]. Here l(3) ≡ l(c) = 1, l(4) ≡ l(d) = 2, l(2) ≡ l(b) = 3, l(1) ≡ l(a) = 4, l(5) ≡ l(e) = 5.

Definition 3 (Partial list): "A list l containing elements, which are a strict subset of U, is called a partial list. We have a strict inequality |l| < |U|."

Definition 4 (Rank Aggregation Problem): "Let us consider following notations; I = {1,2…,i…n} and J={1,2…,j…m}are set of positive integers. Given a set of Universities, wedenote it as U= {U_1, U_2, U_3… U_i … U_n}, here |U| = n. And a set of books, B= {B_1, B_2 … B_j… B_m}. Wesay that the list l_i(k) indicates the k^{th} book recommended by U_i. For each „i" in I, l_i is an injection (one-to-one function) from J to the set of positive reals or integers. l_i(j) <l_i(k) means that university U_i prefers book B_j over book B_k. However, l_i may be partial (i.e. not defined for some j's).The Rank Aggregation Problem is to combine the m ranked lists $l_1, l_2, l_3, \ldots l_m$ into a single list of candidates, say l that represents the collective choice of the university. The function used to get l from $l_1, l_2, l_3, \ldots, l_m$ (i.e $f(l_1, l_2, l_3, \ldots, l_m)$=l) is known as rank aggregation function"

2.1 Product Recommendations Techniques

There are a good numbers of works in the area of product recommendation[8]. There are various methods being used frequently in recommendation techniques. Collaborative filtering, association rule mining, web mining and Content-based Recommendation are most frequently used recommendation techniques found in the literature.

Collaborative Filtering (CF) has been most influential recommendation technique used for online shopping of various applications including electronic products, research articles and web pages, etc[9,10]. Despite of such success, CF still faces many issues for which researchers have opted web mining to deal with. It is found that opinion mining has been widely used for personalized recommendation system[11,12]. To help customer for achieving exact recommendation using click stream a personalized recommender[13,14] is proposed.

User feed-back based recommendation for electronics items are performed by the authors in[15,16]**.** The authors[17] have come up with an approach which combines decision making and data mining techniques. Association rule mining[18] is also used in recommendation. Content based recommendation is useful in order to provide users the products which are similar to the contents of purchased items[19].

Content based which is interchangeably referred as feature based recommendation tries to find items of similar characteristics based on user profiles[21–23]. A good work in the concerned field is also reported in literature[39–42].

2.2 Book Recommendation

The above discussed techniques are used for several product's recommendation, however there are few specific book recommendation efforts made by the researchers in recent years using above techniques.

Mooney[24] proposed a content based book recommendation technique, called LIBRA (Learning Intelligent Book recommendation Agent) that utilized information extraction and a machine learning algorithm.

Jomsri[25] proposes a library book recommendation system based on user profile loaning and association rule. This system is useful for particular resides in the same institute within the same library and campus. The experiment is performed for the specific university only.

The authors[26] present a technique that combined the feature of classification; User based collaborative filtering and association rule mining. The classification technique is used to mine the book with respect to book's features. The latter two techniques are used to know the user's requirement for recommending highly rated books.

A book recommendation system based on digital signage system has been proposed by the authors in[27]. The books are recommended for particulars by identifying age and sex of the users. Here books recommendation

approach is confined and very limited. It cannot be spread to a big community or universities but only for few magazines for the user aged 19-21 of same located schools.

The authors in[28] recommended books for online shopping using web mining technique where they categorized the features from the reviews of the users available online and recommended top computer science books by assigning weights to these features and scoring these values. The authors in the paper searched the book on a specific topic using Google search. The top links are stored and the reviews of the readers for all the stored results are assessed. The features are extracted from the user's review and accordingly the books are ranked.

2.3 Fuzzy based Aggregation Operators

Fuzzy techniques have been used widespread for various scientific and daily life problems. Ordered Weighted Averaging (OWA) operator is a well-known fuzzy based averaging operator[29]. A variety of its applications have been presented in the literature.

Several authors have used OWA operator for various applications[30]. The author (Beg, 2005)[31] used OWA operator based novel fuzzy queries for web searching. The researchers have also applied the OWA operator's application in several GIS environments[32–34].

We have proposed Ordered Ranked Weighted Aggregation operator to recommend books in which we have modified the weight assignment procedure for OWA so that it may make use of the positional rank of the recommending agents.

As mentioned above, computer science books only from the top ranked universities' syllabus are considered. The philosophy behind this is simply incorporating the recommendation from authorities.

3. Positional Aggregation Based Scoring Technique (PAS)

We are concerned with different books prescribed in the syllabus of top ranked universities. The prescribed books may be considered as the rankings of the books by that particular university. The syllabus of respective universities differs significantly. We have got a partial list for the books prescribed in the syllabus by different universities. We aggregate the ranked books to get a final aggregated ranking of the books. For full list, we have several well-known methods like Borda's method[35] Markov chain based methods[36] and soft computing based methods. But these techniques work for full list only[6,35]. Therefore we have applied Positional Aggregation Score (PAS) based technique[7] that can work better to recommend the top books for partial list. The PAS based technique works as follows:

Suppose 'm' different books are recommended by 'n' different universities. First we find out the rank of a book 'B_i' for every university, maximum value is assigned

Table 1. Top 4 ranked books by 5 universities

Top 4 Books	U1	U2	U3	U4	U5
1	B1	B2	B3	B2	B4
2	B2	B4	B1	-	B1
3	B3	-	B4	-	-
4	-	-	-	-	-

Table 2. Conversion of rank into scores

	U1	U2	U3	U4	U5
B1	-1	-5	-2	-5	-2
B2	-2	-1	-5	-1	-5
B3	-3	-5	-1	-5	-5
B4	-5	-2	-3	-5	-1

Table 3. Pairwise comparison of books

Pair (B_i, B_j)	U1	U2	U3	U4	U5
B1,B2	1	0	1	0	1
B1,B3	1	0	0	0	1
B1,B4	1	0	1	0	0
B2,B1	0	1	0	1	0
B2,B3	1	1	0	1	0
B2,B4	1	1	0	1	0
B3,B1	0	0	1	0	0
B3,B2	0	0	1	0	0
B3,B4	1	0	1	0	0
B4,B1	0	1	0	0	1
B4,B2	0	0	1	0	1
B4,B3	0	1	0	0	1

Table 4. Preference score of books

	U1	U2	U3	U4	U5
B1	3	0	2	0	2
B2	2	3	0	3	0
B3	1	0	3	0	0
B4	0	2	1	0	3

Table 5. Normalized preference score of books

	U1	U2	U3	U4	U5
B1	1	0	0.66	0	0.66
B2	0.66	1	0	1	0
B3	0.33	0	1	0	0
B4	0	0.66	0.33	0	1

to first ranked book, i.e., V_{max}= -1 is assigned to B_1. The idea behind assigning '-1' to best ranked book is to give highest value to it and all the values associated to ranked book should be in order of their ranking i.e. better ranked books get a higher numerical value associated with it. For next value, best ranked book is assigned a value {(V_{max}) – (i)} to $(i+1)^{th}$. Above steps are repeated till values are assigned to all books. A value '-(m+1)' is assigned to these books which have no proper place in ranking. Where m is number of total books being ranked by different universities, m = 41. Now, each book 'B_i' is compared with 'm-1' books. If value (B_i) > (B_{m-1}), B_i = 1 otherwise B_i =0; If we find B_i == - (m+1), B_i = 0; finally we find out the sum of all values and call it S. the final score 'FS' is given by (S / (m+1)).

Example 2: we are taking an example with four books and five universities to illustrate the above procedure, i.e., m = 4. U1, U2, U3, U4 and U5 are five different universities and B1, B2, B3, and B4 are four different books. Sequence 1, 2, 3 and 4 are ranking position of the books, i.e. the row consists of '1' in first column will give the first ranked book of the particular university. All the universi-

Table 6. Positional aggregated scores of books

Book	Positional Aggregation Score
B1	0.464
B2	0.532
B3	0.266
B4	0.398

Table 7. Ranked books based on PAS technique

Rank position	Book
1	B2
2	B1
3	B4
4	B3

ties have their own ranking for different books; we give these rankings in Table 1.

Let a cell 'z' is represented by z (r, c), where r and c represent the r^{th} row and c^{th} column respectively. The value of z (1, 1) is B1, i.e., B1 is ranked first by University U1. z (3, 5) is '-' that implies no book is recommended by University U4 except B2 in first four position. In Table 2 rank to score conversion is illustrated where the best ranked university is assigned '-1'. As B1 is first ranked book by University U1, the cell corresponding to B1 and U1 has -1. Those books which are not ranked by any university is assigned a value '-5'.

Table 3 gives the pairwise comparison of respective books. A pair $(B_i, B_j) = 1$ implies that book B_i is preferred over book B_j by the university. If $(B_i, B_j) = 0$, it means book B_j is preferred over book B_i by the university concerned. In Table 4, we showed the sum of values of all the comparison of each book for all the universities.

The value of B1 for U1 comes out to be 3, which means university 'U1' prefers book 'B1' over rest of the three books. There are (m-1) comparisons for each book; hence the values obtained in Table 4 can be normalized by dividing 3.

The normalized score is given in Table 5. We call it normalized preference score. Finally we get Positional Aggregated Score by dividing the values obtained in Table 5 by number of university 'n', here n = 5. The values are given in Table 6. Finally we sort the PAS to find top books, as shown in the Table 7. The above calculation is summarized in an algorithm and shown in Figure 1. The

Preliminaries:

- *Total no .of books is 'm'*
- *Total no. of different universities is 'n', hence total 'n' ranking is available*
- *For each book B_i belongs to m, we have different ranked position of B_i in every ranking R_k ; $1 \le k \le n$ i.e. we have a matrix with m rows and n column may be represented as: R[i,k] where $1 \le i \le m$ & $1 \le k \le n$;*

Steps:

Repeat the following procedure till steps7 for every ranking R_k

1: find out the rank of a book 'B_i' where, $1 \le i \le m$

2: Assign maximum value (Vmax= -1) to book which is best ranked

3: For next value, assign (Vmax – i) to $(i+1)^{th}$ best ranked book

4: If a book is not ranked, assign it a value = – (m+1)

Repeat the steps 2 to 4 until all the books are assigned a value, store these values in a matrix SM [i, k];

5: compare each book 'B_i' with each of the remaining 'm-1' books, for $1 \le i \le m$

If

$$SM[i,k] > SM[j,k],\ 1 \le j \le m;\ i \ne j$$

{

PC [i,k] = 1;

}

else

PC [i,k] =0;

6: we find preference score matrix PSM [i,k] such that

$$PSM[i,k] = \sum_{j=1}^{m} (Bi, Bj);\ j \ne i$$

7: create normalized matrix NM [i,k] = PSM [i,k] /(m-1);

8: we find positional aggregation based scores as:

$$PAS = \left(\frac{1}{n}\right) \sum_{i,k=1}^{m,n} NM[i,k]$$

Figure 1. Algorithm for positional aggregation based scoring technique.

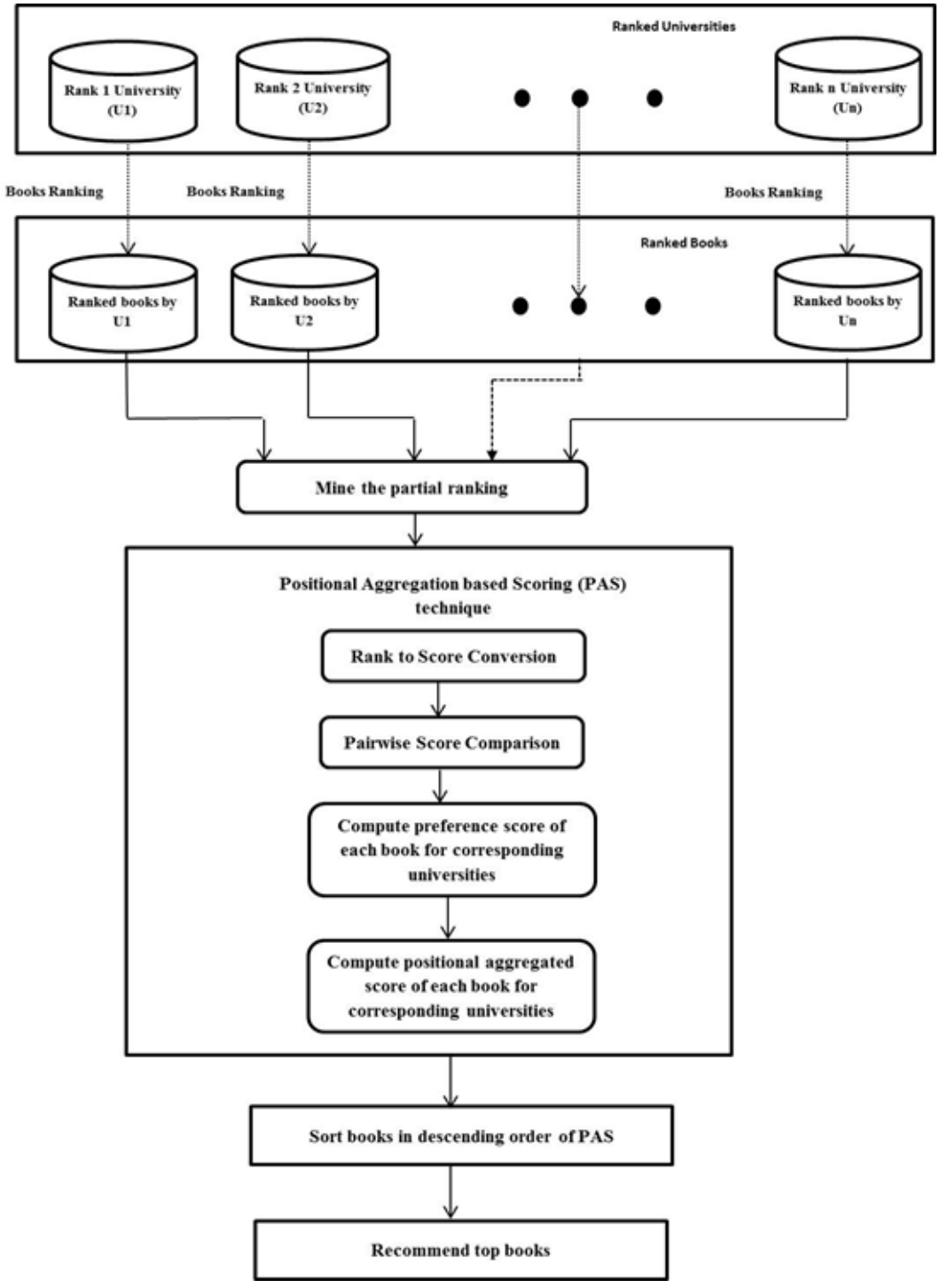

Figure 2. Positional aggregation scoring based book recommendation system.

algorithm is explained below; however, Figure 2 explains the procedure pictorially.

The preliminaries are the prior information for applying Positional based aggregation technique. If we consider example 2; the preliminaries are stored in the Table 1, the step 2 to step 4 is tabulated in Table 2. In Step 5 we generate values in terms of 0 and 1 that compares all the books pairwise. Table 3 gives values for these pairwise comparisons. The preference scores give the idea about a book that how many books are there by which a particular book is preferred by each university. These scores are stored as directed in Step 6 and tabulated in Table 4.

To normalize the scores, we perform step 7 and the normalized score is given in Table 5. Final Positional Aggregation based Scores (PAS) are computed as formula given in step 8. The final PAS scores and ranks are given in Table 6 and Table 7 respectively. The block diagram for the complete process of Positional Aggregation based Scoring technique is depicted in Figure 2 The architecture being represented by the block diagram in the Figure 2 gives an idea of how the different books which are recommended by top ranked universities are quantified and scored. The step wise pictorial illustration is given below. The first block of the diagram represented in Figure 2 have different ranked universities and store the books ranked by these universities. The next block shows the PAS technique applied on the obtained ranking as discussed above. Finally we get ranked books by PAS technique.

4. Ordered Ranked Weighted Aggregation based Book Recommendation

In this section we have discussed the Ordered Ranked Weighted Aggregation (ORWA) based book recommendation technique. As ORWA is a modified form of Ordered Weighted Aggregation (OWA), first we explain OWA with example.

4.1 Ordered Weighted Aggregation (OWA)

Ordered weighted aggregation operator is very useful for aggregating multiple criterions[38]. Mathematically we give OWA as;

$$\text{OWA}(x1, x2, \ldots, xn) = \sum_{k=1}^{n} w_k z_k \quad (1)$$

Where zk implies that if we re-order the values x1, x2 , … xn in descending order, we get a sequence z1, z2, .. , zn i.e. z1≥ z2≥ ,… zn-1≥zn. The weights 'Wk' for OWA operator is calculated by using following Equation

$$Wk = \{Q(k/m) - Q((k-1)/m)\}, \quad (2)$$

Where k = 1, 2… m.

Function Q(r) for relative quantifier can be calculated as:

$$Q(r) = \begin{cases} 0 & \text{if } r<a \\ \dfrac{(r-a)}{(b-a)} & \text{if } a\le r \le b \\ 1 & \text{if } r>b \end{cases} \quad (3)$$

Where Q (0) = 0, ∃r ε [0, 1] such that Q(r) =1, and a, b and r ε [0,1].

Example 2: For number of criteria (m) = 5 and parametric values as a=0 and b=0.5, we will have corresponding weights for OWA values as:

w (1) =0.4, w (2) =0.4, w (3) =0.2, w (4) =0.0, w (5) =0.0.

In the same way, for a=0.3, b=0.8 we obtained values of weights as; w (1) =0.0, w (2) =0.2, w (3) =0.4, w (4) =0.4, w (5) =0.0.

For a=0.5, b=1.0 we obtained values of weights as;w (1) =0.0, w (2) =0.0, w (3) =0.2, w (4) =0.4, w (5) =0.4.

4.2 Ordered Ranked Weighted Aggregation (ORWA)

Ordered Weighted Aggregations (OWA) has been widely used in computational intelligence because of its strength in modeling the multi criteria decision making problems[34]. OWA is a very powerful fuzzy aggregation operator but it works when no consideration is required to be given

Table 8. Ranked books based on ORWA technique for Example 2

Rank Position	Ranked Books
1	B2
2	B1
3	B3
4	B4

for voters. For preference based voters, i.e. some voters have preference over other; a weighting system is required which takes these p preferences into account. Hence, we have proposed Ordered Ranked Weighted Aggregation (ORWA) operator that takes into account the importance of the ranking agents.

The application of ORWA may influence several real life decision making problems. In fact, ORWA may be ideally useful in all decision making problems where the recommendations are given by the experts, and we need to weight the experts or rankers. The ORWA would be very helpful in the recommendations of Voting results, sports team, universities preferences and web sites selections etc.

We assign aggregation weights 'v' to different universities using formula;

$$v_i = \frac{n+1-i}{N} \quad (4)$$

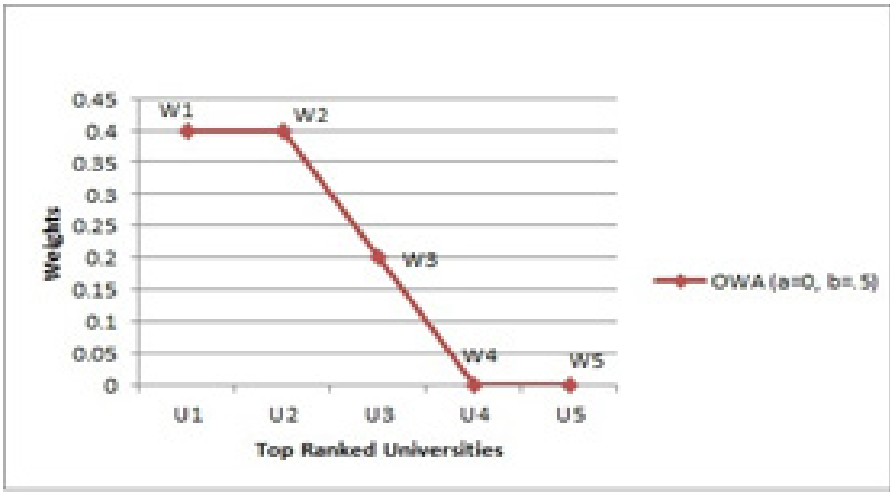

Figure 3. Weights assigned to top universities by OWA with a=0 and b=0.5.

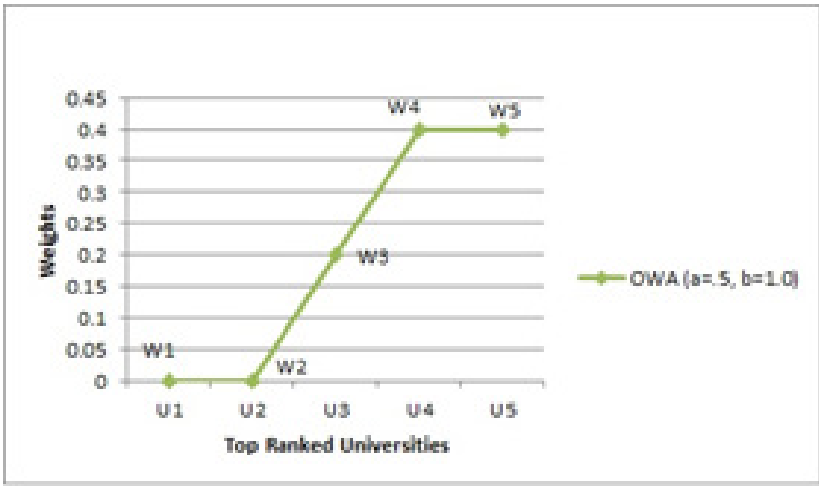

Figure 4. Weights assigned to top universities by OWA with a=.5 and b=1.0.

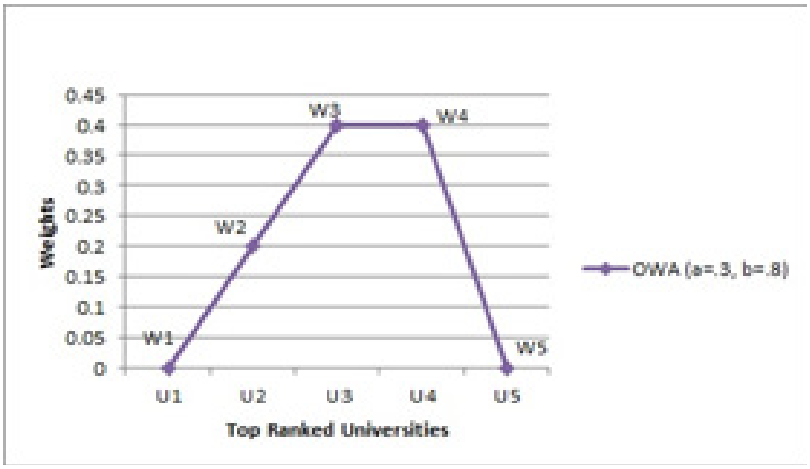

Figure 5. Weights assigned to top universities by OWA with a=.3 and b=.8.

Where, n is the number of universities. N is given by;

$$N = \sum_{i=1}^{n} (i).$$

And i=1,2,3…n.

'i' indicates the i^{th} ranked university i.e., i = 1 means first ranked university, i = 2 means second ranked university, and so on.

Also the weights 'v_i' fulfill the following conditions;

$v_i \in [0,1]$

$$\sum_{1}^{n} v_i = 1.$$

Further, v_i indicates the weights assigned to the i^{th} ranked university, i.e. the best ranked university is asso-

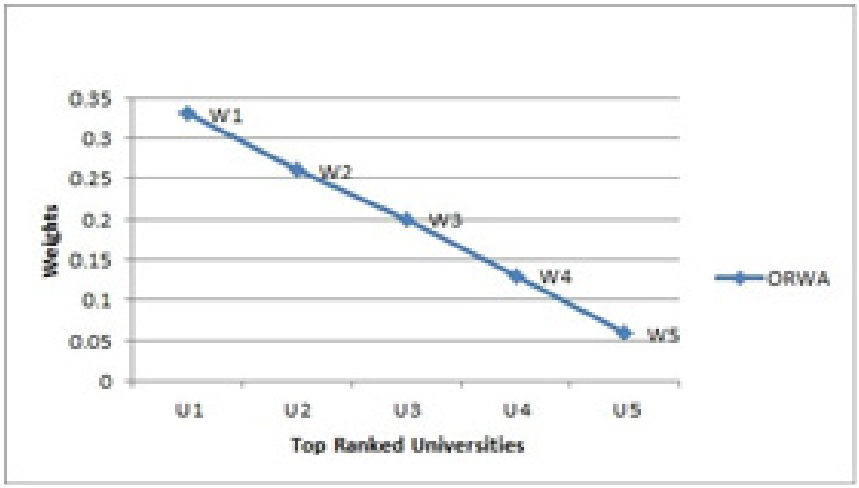

Figure 6. Weights assigned to top universities by ORWA.

ciated with a maximum weight to it, and hence more preferred over other least ranked universities. Thus $v_i > v_j$ for i<j. i.e., for five different ordered ranked universities U_1, U_2, U_3, U_4 and U_5, ordered in best to least ranks; we have v1>v2>v3>v4>v5.

Example 3: For five different universities we have m=5 that gives N = 15, thus we get five values of weights as: $v_1 = 1/3 = 0.3333$, $v_2 = 4/15 = 0.2666$, $v_3 = 1/5 = 0.20$, $v_4 = 2/15 = 0.1333$, $v_5 = 1/15 = 0.0666$.

We give formula to obtain ORWA as;

$$\text{ORWA} = \sum_{i=1}^{n} v_i y_i \qquad (5)$$

v_i is given by the Equation (4) and y_i is the score given to a book by i^{th} ranked university.

We refer to Table 5 we have preference scores of books for five ranked universities. Considering equation V, we get $y_1=1.0$, $y_2=0.0$, $y_3=0.66$, $y_4=0.0$ and $y_5=0.66$. We apply the above values and weights obtained in example3 to equation V.

$$ORWA = (0.3333 \times 1) + (0.2666 \times 0) + (0.20 \times 0.66) + (0.1333 \times 0) + (0.0666 \times 0.66)$$
$$= 0.0566$$

In the similar way we will be getting different values for book B2, B3 and B4. The values obtained are as follows:

B1 = 0.4439292, B2 = 0.619878, B3 = 0.309989, B4 = 0.308556

The final ranking is tabulated in Table 8.

We can easily see the difference of the weights obtained by the OWA operator and ORWA operator as calculated in Section 4.1 and 4.2 respectively. The OWA operator has W_1 as 0 as well in several cases which would be associated with highest scored ranker that eventually will make the final value zero. i.e., the most valuable ranker may get '0' value whereas the ORWA operator, which has a modified way of assigning weights to OWA, considers the strategy that highest weights should be assigned to most valuable ranker, in our case the best ranked university. The graphical representation of the weights assignment is shown in Figure 3, 4, 5 and 6 respectively.

We associate a specific weight to each university which is recommending a book, and use ORWA technique as described by Equation (5). A block diagram for whole procedure is given in Figure 7. The detail discussion on the results is done in the Section 5.

5. Results and Discussions

The work done in the paper is however seems very specific to the books for Indian University only, but the idea can be integrated to any situation where ranker's recommendations are provided along with the rank of the rankers.

For our experiment, we mined top 50 ranked Indian universities from www.career360.com, out of which only 22 universities' data were found relevant to be included in our study.

Table 9. Weights assigned to different universities using ORWA technique

Ranked Universities sequence	weights
1	.0869
2	.0830
3	.0790
4	.0750
5	.0711
6	.0671
7	.0632
8	.0592
9	.0553
10	.0513
11	.0474
12	.0434
13	.0395
14	.0355
15	.0316
16	.0276
17	.0237
18	.0197
19	.0158
20	.0118
21	.0079
22	.0039

Table 10. ORWA and PAS based scores of books

Books	PAS based Scores	ORWA based scores
B1	0.705	0.6972
B2	0.299818	0.3178
B3	0.290091	0.2726
B4	0.134	0.1614
B5	0.391762	0.3829
B6	0.654818	0.5896
B7	0.041955	0.0766
B8	0.040773	0.0744
B9	0.039591	0.0722
B10	0.038455	0.0702
B11	0.245773	0.2557
B12	0.085045	0.0917
B13	0.043091	0.0674
B14	0.205045	0.1974
B15	0.045455	0.0632
B16	0.044273	0.0615
B17	0.043091	0.0599
B18	0.041955	0.0583
B19	0.040773	0.0567

Table 10 Continued

B20	0.039591	0.0550
B21	0.089727	0.0745
B22	0.134238	0.1303
B23	0.083864	0.1102
B24	0.125818	0.0767
B25	0.160773	0.0989
B26	0.040773	0.0283
B27	0.038455	0.0267
B28	0.039048	0.0259
B29	0.034955	0.0243
B30	0.033773	0.0234
B31	0.031455	0.0218
B32	0.041955	0.0255
B33	0.041955	0.0218
B34	0.040773	0.0212
B35	0.045143	0.0187
B36	0.041955	0.0109
B37	0.043091	0.0037
B38	0.036091	0.0251
B39	0.044273	0.0038
B40	0.037273	0.0032

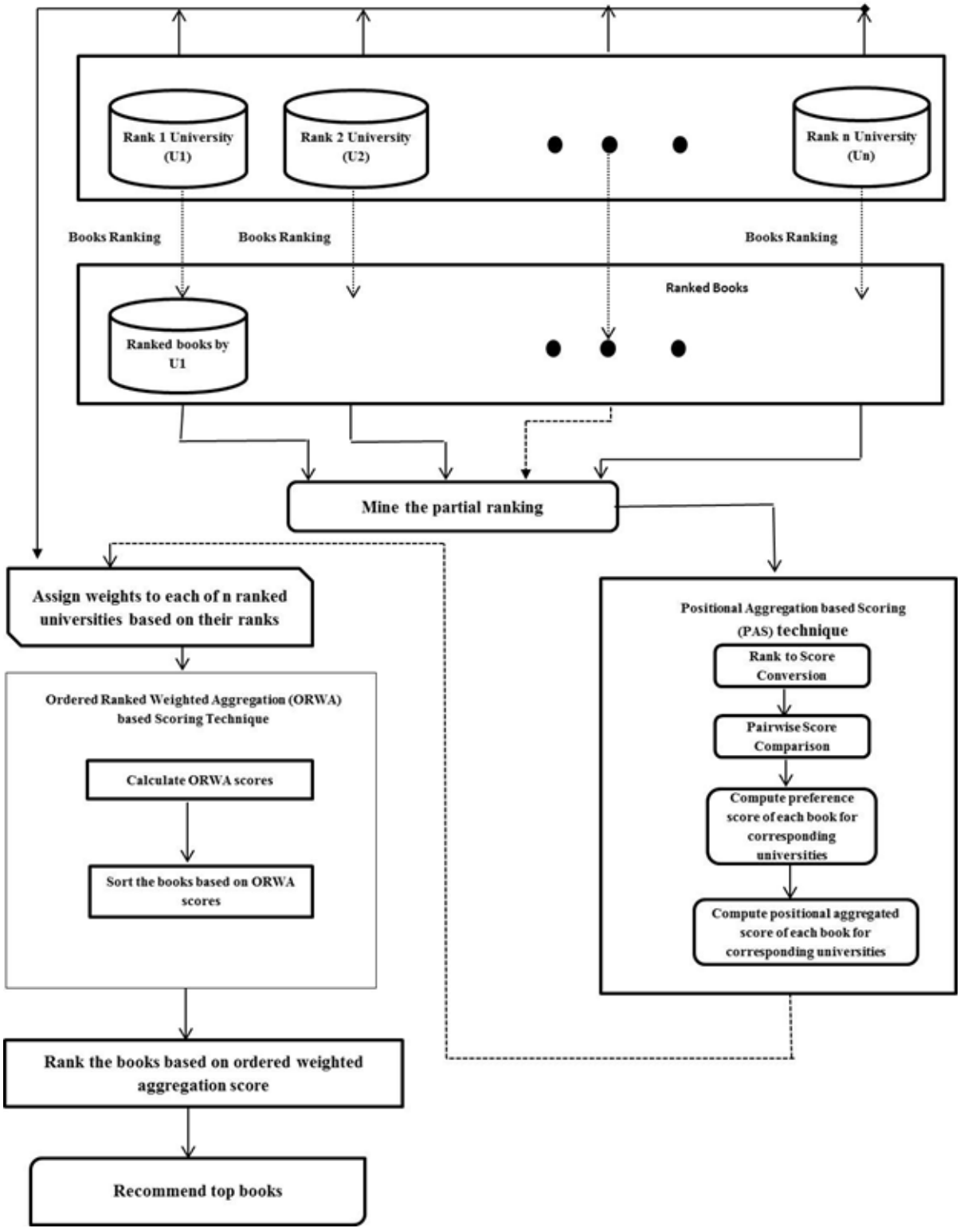

Figure 7. Ordered ranked weighted aggregation based book recommendation system.

Table 11. PAS based scores of each book for corresponding universities

Books	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
B1	1	0	1	1	1	0	.820	.948	0	.923	.974	1	0	.974	0	1	1	1	1	.871	1	0
B2	.974	0	0	0	.9	0	0	0	.974	.9	0	0	1	0	0	0	0	.948	0	.9	0	0
B3	.820	0	.974	0	0	0	0	0	0	1	0	.948	0	0	0	0	0	.923	0	.846	0	.871
B4	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	.948	0	0
B5	0	.974	0	0	.923	.948	.769	0	0	0	.948	0	.923	0	.871	0	0	0	0	.974	0	.897
B6	0	.948	0	.974	.974	0	.846	0	0	.846	1	.974	.948	1	1	.974	.974	0	.974	0	.974	1
B7	0	.923	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B8	0	.897	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B9	0	.871	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B10	0	.846	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B11	0	0	0	.948	.871	0	0	.974	0	0	0	0	.974	0	.717	0	0	0	0	0	0	.923
B12	0	0	0	.923	0	0	0	0	0	0	0	0	0	0	0	0	.948	0	0	0	0	0
B13	0	0	0	0	.948	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 11 Continued

B14	0	0	0	0	.846	0	0	1	0	.974	0	0	0	0	0	.897	0	0	0	0	0	.794
B15	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B16	0	0	0	0	0	0	.974	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B17	0	0	0	0	0	0	.948	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B18	0	0	0	0	0	0	.923	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B19	0	0	0	0	0	0	.897	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B20	0	0	0	0	0	0	.871	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B21	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	.974	0	0	0	0
B22	0	0	0	0	0	0	0	0	.948	.948	0	0	0	0	.923	0	0		0	0	0	0
B23	0	0	0	0	0	.974	0	0	0	.871	0	0	0	0	0	0	0	0	0	0	0	0
B24	0	0	0	0	0	0	0	0	0	0	0	.923	0	0	0	0	.948	0	.897	0	0	0
B25	0	0	0	0	0	0	.794	0	0	0	0	0	0	0	.974	0	0	0	.923	0	0	.846
B26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.897	0	0	0	0	0	0	0

Table 11 Continued

B27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.846	0	0	0	0	0	0	0
B28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.820	0	0		0	0	0	0
B29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.769	0	0	0	0	0	0	0
B30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.743	0	0	0	0	0	0	0
B31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.692	0	0	0	0	0	0	0
B32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.923	0	0	0	0	0	0
B33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.923	0	0	0	0	0
B34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.897	0	0	0	0	0
B35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		.948	0	0	0
B36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.923	0	0
B37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.948
B38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.794	0	0	0	0	0	0	0
B39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.974
B40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.820

Table 12. Comparison of PAS and ORWA based techniques

PAS based ranking	ORWA based Ranking
B1	B1
B6	B6
B5	B5
B2	B2
B3	B3
B11	B11
B14	B14
B25	B4
B22	B22
B4	B23
B24	B25
B21	B12
B12	B24
B23	B7
B15	B21
B35	B8
B16	B9
B39	B10
B13	B13
B17	B15

Table 12 Continued

B37	B16
B7	B17
B18	B18
B32	B19
B33	B20
B36	B26
B8	B27
B19	B28
B26	B32
B34	B38
B9	B29
B20	B30
B28	B33
B10	B31
B27	B34
B40	B35
B38	B36
B29	B39
B30	B37
B31	B40

Table 13. Top 20 books recommended by PAS based recommendation system

Ranking	Book Code	Author	Title	Publisher & Year
1.	B1	S. Russel and P. Norvig	Artificial Intelligence - A Modern Approach	Prentice Hall, 1995
2.	B6	E. Rich and K. Knight	Artificial Intelligence	Addison Wesley, 1990
3.	B5	P. H. Winston	Artificial Intelligence	Addison Wesley, 1993
4.	B2	G. F. Luger	A.I: Structures and Strategies for complex problem solving	Pearson Education, 2002
5.	B3	Nils J. Nilsson	Artificial Intelligence - A New Synthesis	Morgan Kaufmann Publishers, 2000
6.	B11	D W Patterson	Artificial Intelligence - A New Synthesis	Prentice Hall of India, 2002
7.	B14	A.J. Nillson	Principles of AI	Narosa publications, latest Edition
8.	B25	Charniak, Resibeck & Mcdermott	Artificial intelligence Programming	Lawrence Erlbaum associates, Hills dale, NJ (1983)
9.	B22	N. J. Nilsson.	Problem-Solving Methods in Artificial Intelligence	New York: McGrawHill, 1971
10.	B4	E. Charniak, et.al.	Introduction to Artificial Intelligence	Addison Wesley, 1985

Table 13 Continued

11.	B24	I. Bratko	Prolog Programming for Artificial Intelligence	3rd Ed., Pearson Education. 2001
12.	B21	D. Poole, A. Mackworth & R.Goebel	Computational Intelligence : a logical approach	Oxford University Press, 2004.
13.	B12	W. F. Clocksin and C. S. Mellish	Programming in Prolog	5th Edition Springer-Verlag, 2003
14.	B23	M. Ginsberg	Essentials of Artificial Intelligence	Morgan Kaufman Publishers, 1993
15.	B15	Deepak Khemani	A First Course in Artificial Intelligence	McGraw Hill Education (India), 2013
16.	B35	P. H. Winston and B. K. P. Horn	Lisp	3rd Ed, Addison-Wesley, 1989
17.	B16	Stefan Edelkamp and Stefan Schroedl	Heuristic Search: Theory and Applications	Morgan Kaufmann, 2011
18.	B39	J. L. Ermine	Expert Systems : Theory and Practice	PHI
19.	B13	Saroj Kaushik	Artificial Intelligence	Cengage Learning, 2011
20.	B17	John Haugeland	Artificial Intelligence: The Very Idea	The MIT Press, 1985

Table 14. Top 20 books recommended by ORWA based recommendation system

Ranking	Book Code	Author	Title	Publisher & Year
1.	B1	S. Russel and P. Norvig	Artificial Intelligence - A Modern Approach	Prentice Hall, 1995
2.	B6	E. Rich and K. Knight	Artificial Intelligence	Addison Wesley, 1990
3.	B5	P. H. Winston	Artificial Intelligence	Addison Wesley, 1993
4.	B2	G. F. Luger	A.I: Structures and Strategies for complex problem solving	Pearson Education, 2002
5.	B3	Nils J. Nilsson	Artificial Intelligence - A New Synthesis	Morgan Kaufmann Publishers, 2000
6	B11	D W Patterson	Artificial Intelligence - A New Synthesis	Prentice Hall of India, 2002
7.	B14	A.J. Nillson	Principles of AI	Narosa publications, latest Edition
8.	B4	E. Charniak, et.al.	Introduction to Artificial Intelligence	Addison Wesley, 1985
9.	B22	N. J. Nilsson.	Problem-Solving Methods in Artificial Intelligence	New York: McGrawHill, 1971
10.	B23	M. Ginsberg	Essentials of Artificial Intelligence	Morgan Kaufman Publishers, 1993

Table 14 Continued

11	B25	Charniak, Resibeck & Mcdermott	Artificial intelligence Programming	Lawrence Erlbaum associates, Hills dale, NJ (1983)
12.	B12	W. F. Clocksin and C. S. Mellish	Programming in Prolog	5th Edition Springer-Verlag, 2003
13.	B24	I. Bratko	Prolog Programming for Artificial Intelligence	3rd Ed., Pearson Education. 2001
14.	B7	R. Honavar and E. Uhr	Artificial Intelligence and Neural Networks.	Academic Press, 1992
15.	B21	D. Poole, A. Mackworth & R.Goebel	Computational Intelligence : a logical approach	Oxford University Press, 2004.
16.	B8	F. Hayes Roth et.al.	Building Expert Systems	Addison Wesley, 1983
17.	B9	P. R. Cohen,et.al.	The Handbook of Artificial Intelligence, Vol.1,2 and 3.	Kaufman Inc.,1982
18.	B10	J. Carbonell	Machine Learning paradigms and Methods	MIT Press, 1990
19.	B13	Saroj Kaushik	Artificial Intelligence	Cengage Learning, 2011
20.	B15	Deepak Khemani	A First Course in Artificial Intelligence	McGraw Hill Education (India), 2013

The different universities have different syllabus and covers various courses. In this paper "Artificial Intelligence" (AI) is selected as a course of Computer Science. the details of AI are stored and as per the ranking of the books by respective universities, each book is assigned a score. Books by corresponding get different scores. Table 9 consists of these scores.

In Table 9, codes B1, B2 etc. are the codes for different books and the scores assigned to each book for corresponding universities are tabulated. E.g. in cell (1, 1) i.e., first row and first column value is '1'; it implies that book 'B1' is ranked 1 by University 'U1'.

As discussed in Section 5.2, we get different values of weights for all the 22 universities, the weights are depicted in Table 9. These weights signify that the higher rated universities, i.e., universities which are best ranked are associated with a high value of weights to it. The weights are assigned to each university using Equation (4).

These weights are used to obtain corresponding Ordered Ranked Weighted Aggregation (ORWA) scores as described in Section 5.2.

The corresponding ORWA and PAS based values are given in Table 10. In Table 11 the comparison of the PAS based ranking and ORWA based ranking is done. Table 12 and Table 13 give top 20 ranked books, these books are final recommended books with their complete details for Positional Aggregation based Scoring (PAS) and Ordered Ranked Weighted Aggregation (ORWA) techniques respectively. The details of books include book title, author name, publisher and year along with the book code, including book ID which has been used in the paper.

If we analyze the final recommendations in Table 13 and Table 14, we find that at top seven positions, the recommended books by both the methods are same. But there is difference in recommendation from position 8 to 10. Therefore top 10 ranking has almost same recommendation by both the methods but ranking positions of books B22 and B4 is different, also book 'B25' is ranked 8th by PAS method and included in top 10 positions whereas ORWA technique does not give B25 top 10 positions and it ranks B23 at 9th position. B25 is ranked 11th by ORWA.

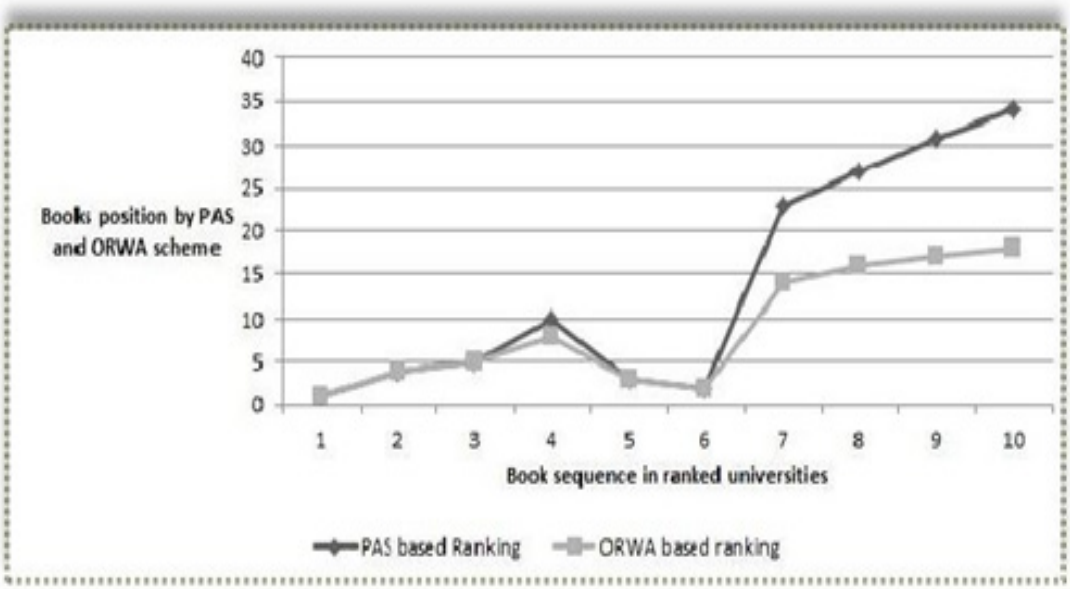

Figure 8. Relative comparison of PAS and ORWA for books B1-B10.

However, from position 11 to 20 we have several different books in both recommendations. ORWA technique includes the top ranked universities' ranking whereas PAS has the different recommendation. i.e., the recommendation of top ranked universities is involved more in ORWA than in the PAS technique. B7, B8, B9, and B10 are the books recommended by the universities which are ranked 7, 8, 9 and 10 respectively. These books are recommended and included by ORWA technique but not by PAS. The main advantage of applying ORWA technique over PAS technique is the inclusion of rank of the rankers and fuzzy preferences that can give the recommended books-ranking's positions along with the total recommended books. The strength of assigning weights to the rankers in the ORWA provides a better recommendation process and hence better ranked books can be presented before the users. In Figure 8, we have illustrated that how rank position of books recommended by top ranked universities without any consideration, and that of PAS and ORWA differ. The book code B1 simply indicates a book which is ranked at top position by first ranked university. Similarly, B2 is the second best book by first ranked university or top book by second ranked university. In the same way we have numbered books B1 to B10. The graph in Figure 8 shows ORWA has comparatively better ranking for B1 to B10 than PAS scheme. The main advantage of applying ORWA technique over PAS technique is the inclusion of rank of the rankers and fuzzy preferences that can give the recommended books-ranking's positions along with the total recommended books. The strength of assigning weights to the rankers in the ORWA provides a better recommendation process and hence better ranked books can be presented before the users.

6. Conclusion

We have introduced two different schemes to recommend books. First, a rank aggregation algorithm based recommendation of books, we call it, 'Positional Aggregation based Scoring (PAS) technique' and second, we have proposed a fuzzy based aggregation operator, 'Ordered Ranked Weighted Aggregation (ORWA)' and suggested a recommendation technique that makes use of the first scheme along with the proposed ORWA.

The Ordered Ranked Weighted Aggregation incorporates rank of the rankers to emphasize the importance of the rankers as a book recommended by best ranked institution must get high preference than a book which is recommended by a lower ranked institution. The ORWA gives the ranking positions of the recommended books, along with the total recommended books. The strength of assigning weights to the rankers in the ORWA provides a better recommendation. Since we do not have any benchmark for ranking the books, we can rely on the best ranked universities' recommendation (syllabus). We believe the proposed technique may meet the user's need and provide them the perfect books they need. Further, we can generalize the procedure of the recommendation for any kind of items.

The top 20 books on Artificial Intelligence for Indian Universities are recommended using both techniques. The comparisons of both the methods are shown.

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