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Ranking cricket teams

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ABSTRACT

Teams are ranked to show their authority over each other. Existing methods rank the cricket teams using an ad-hoc points system entirely based on the winning and losing of matches and ignores number of runs or wickets from which a team wins. In this paper, adoptions of h-index and PageRank are proposed for ranking teams to overcome the weakness of existing methods. Each team is represented by a node in the graph with two teams creates a weighted directed edge between each other by playing a match and the losing team points to the winning team. The intuition is to get more points for a team winning from a stronger team than winning from a weaker team by considering the number of runs or wickets also in addition to just winning and losing matches. The results show that proposed ranking methods provide quite promising insights of one day and test team rankings. The effect of damping factor d is also studied on the performance of PageRank based methods on both ODI and test matches teams ranking and interesting trends are found.

1. Introduction

Sports ratings are performed for showing the standings of different teams and players by analyzing the results of competitions or matches. The team with the highest points is usually ranked number 1. Traditional sports rankings are based on win, loss or tie ratios or polls which are subjective rating of the teams, such as, ICC cricket rankings are based on many ad-hoc rules.[1] Borooah and Mangan (2010), criticized that current point system based ranking schemes are opaque, so the methods used by ICC for rankings of cricket teams and players still needs to be investigated properly to provide better ranking methods.

State-of-the-art indexing and ranking algorithms such as h-index (Hirsch, 2005) and PageRank (Page, Brin, Motwani, & Winograd, 1998), respectively can be adopted to rank cricket teams. H-index indexes researcher in co-author network on the basis of a sort of average citations received by him for her papers. The more the average citations received by a researcher the higher the h-index she has. The number of runs and wickets from which matches are won can be thought of as citations. The intuition is that the more the average number of runs or wickets from which matches are won by a team the higher the index she has. This idea is supported by the fact that in case of more than two teams in a series, if two teams have same points the team with better run rate is considered better by ICC. The run rate is calculated by using number of runs and wickets of team's previous winnings and losings but this factor is ignored in the ICC cricket rankings. PageRank (Page et al., 1998) is used to rank web pages on the basis of inlinks and the importance of those pages that are providing those

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[1] http://www.ehow.com/how_6916968_calculate-icc-rankings.html.

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inlinks. The more the number pages providing inlinks as well as they are important the higher the PageRank of the page. The nodes in a graph can be taken as teams and the links between them are the matches played between them. If a team A wins from another team B, team B will provide an inlink to team A. In this way a directed graph is built which can be used to rank teams by considering graph weightage in addition to simply considering the number of won or lost matches.

We propose Team-index (t-index) (non-graph weightage, as it does not consider the weight of the nodes with which matches are played) for indexing teams which is an adoption of h-index (Hirsch, 2005). T-index considers only the number of runs and wickets from which matches are won, while the strength and weakness of the teams from which a team wins is ignored. Consequently, to consider the strength and weakness of teams from which a team wins we propose TeamRank (TR) (graph weightage, as it does consider the weight of the nodes with which matches are played) which is an adoption of PageRank (Page et al., 1998). The intuition is that the more a team wins matches from the stronger teams the higher it will be ranked. TR considers the strength and weakness of the teams from which a team wins while ignores the number of runs and wickets from which matches are won. Consequently, we propose weighted TeamRank (WTR) which also considers the weight of number of runs and wickets from which a team wins from other teams. The intuition is that if a team wins from more runs or wickets the higher it will be ranked. WTR considers number of winnings, number of runs and wickets, simultaneously. Finally, the t-index (non-graph weightage) is merged with WTR (graph weightage) to propose hybrid method. The results and discussions prove that our proposed methods are useful and should be used to rank cricket teams. The behavior of damping factor d is also studied for different PageRank based ranking methods for ODI and test matches teams' rankings to find suitable values for each of the proposed methods in this paper. Our proposed methods are quite flexible and can be easily applied for T20 teams ranking as well.

The contributions in this work are as follows, (1) proposal of graph and non-graph weightage based ranking algorithms for cricket teams ranking, (2) addition of parameters (number of runs and wickets) instead of simply using match won or lost information for graph weightage (3) hybridization of non-graph weightage and graph weightage based ranking algorithms to provide a unified solution and (4) study of the affect of damping factor on different PageRank based ranking methods for cricket teams rankings of ODI and test matches.

The rest of the paper is organized as follows. Section 2 introduces the basic concepts and terminologies followed by related work in Section 3. Section 4 provides the existing ICC cricket ranking method and our proposed four methods for ranking teams. Section 5 provides dataset and detailed results and discussions for ranking teams in different scenarios. Section 6 finally concludes this work.

2. Basic concepts and terminologies

2.1. Team structure

Batsman, bowler, all-rounder and wicket keeper are four roles of players in a cricket team. Batsman uses a bat to score runs, bowler bowls with a ball to batsman to get him out, all-rounder is a player which is able to both bat and bowl and wicket keeper is a player which stands behind the wickets to capture the ball bowled by the bowler in case it is missed by the batsman.

A cricket team consists of eleven players in the ground and a 12th player which enters the ground to replace injured player. Two teams play a match as opponents. One player from each team plays the role of captain. Toss is performed to decide which team will bat and which team will bowl. The toss wining captain decides that her team will bat or bowl. The team bats first have to play the allotted overs bowled by the bowlers of other team to score runs. The team score more runs wins the match.

2.2. Ground

Ground is usually a circle shaped plot with radius 70 m where the match is played. There can be different size grounds all over the world such as 60 m and also 95 m.

2.3. Pitch

Pitch is 22 m area on which wickets are on both sides and bowlers bowls and batsman tries to hit the ball.

2.4. Over

An "over" is defined as a set of six balls bowled consecutively by a bowler.

2.5. Scoring

Each over has six balls. Bowler bowls and batsman hits the ball with a bat to score runs. There can be no run on a ball or maximum 6 runs can be scored by the batsman when the ball hit by her falls outside the boundary line. Four runs are scored

if the ball hit by the batsman roll across the boundary line. Runs can also be scored by the batsman when she hits the ball and runs on the pitch to reach to other side. When a batsman reaches the other side of the pitch after hitting the ball she completes one run. Batsman can score maximum 6 runs by hitting the ball and running on one ball. There are two batsman's playing on the pitch at the same time one on each side with only one facing the bowler. When one batsman hits and scores even number of runs she again faces next ball bowled by the bowler and if batsman hits and scores odd number of runs the batsman on the other side of pitch faces the next ball in case the over is not finished. Each time the over of 6 balls is finished another bowler bowls an over from the other side of pitch.

Here, it is necessary to mention that in cricket game one team bat first and score runs while other team bowls. So in case team batting first wins it wins from runs while in case team batting second wins it wins from wickets. This is why teams can win from runs and wickets both in different matches.

2.6. One day internationals (ODI)

ODI cricket matches are the faster, typically completed in one day, and with a maximum of 50 over's permitted per team. Both teams have to play 50 overs in a day and the team that scores more runs or achieve the target given by other team with saving some wickets wins the match.

2.7. Test matches

Test cricket matches can last up to five days in which each team can play two innings, with each day broken into three sessions punctuated by lunch and tea breaks. Each team has to bat twice in test match so in total there are four innings (innings means a team finishes batting or other team finishes bowling), two for each team. Each day a team can usually play maximum 90 overs but in total a team can play any number of overs in test matches. There is no restriction like 50 overs restriction in ODI matches. The teams can win from wickets and runs and sometime even one innings plus some wickets or runs.

2.8. International Cricket Council (ICC)

The international governing body of cricket is International Cricket Council (ICC). ICC awards championship trophies to the teams with highest ratings in both ODI and test matches. ICC is also responsible for making new rules and making amendments in the existing rules for cricket.

3. Related work

There is not much work done about cricket teams ranking using state-of-the-art indexing and ranking methods, such as h-index (Hirsch, 2005) and PageRank (Page et al., 1998), respectively. In this section, h-index, PageRank and its extensions are discussed followed by PageRank adoptions for different networks. Finally, several social network analysis contributions made for sports teams including cricket teams are explained.

3.1. H-index and its major extensions

H-index (Hirsch, 2005) was proposed for scientist's productivity indexing in co-author networks. It considers both number of papers and citations received by those papers. Although h-index received a lot of attention but its inability to not provide scientist an edge on the basis of their highly cited papers is discussed by Egghe (2006) and G-index was proposed. In it highly cited papers are given extra weightage.

Both h-index and g-index ignored number of years in which the scientist has published papers and received citations for his papers. Consequently (Burrell, 2007) has proposed m-quotient by including career length in existing indexing method h-index. The h-index value of scientist is divided by the number of years of his research activity. These methods have not been explored much for other domains such as teams and players indexing and needs to be explored.

3.2. PageRank and its major extensions

PageRank (Page et al., 1998) was first used for ranking web pages. Several successful attempts are made for the improvement of PageRank. PageRank computes a single vector for whole graph to rank results for all queries. It provides query independent importance of web pages. In order to get more realistic results dependent on query based importance topic-sensitive PageRank was proposed by Haveliwala (2002). In it several PageRank vectors were computed based on topic relevance of pages. The main idea was to rank web pages on the basis of same topic web pages linking to them and their importance on that topic.

The problem of treating all links equally when rank scores are being calculated is raised and Weighted PageRank Algorithm was proposed by Xing and Ghorbani (2004). It takes both inlinks and outlinks importance into account and distributes

rank scores based on the popularity of web pages. Results show that the weighted algorithm can retrieve large number of web pages related to a query as compared to traditional PageRank algorithm.

Time factor importance in order to find authoritative web pages was highlighted and Time-Weighted PageRank was proposed (Manaskasemsak, Rungsawang, & Yamana, 2011). Three different metrics age, event and trend related to time were considered, where, age measures recentness, event means occurrence of some special event and trend in revisions of the web page. Results were compared with the PageRank results and it is found that Time-Weighted PageRank produces more accurate results near to human thinking. And age factor was most important in web pages ranking as compared to event and trend.

3.3. PageRank adoptions

PageRank was a very useful algorithm for ranking objects or finding important nodes in the graphs. It has been applied to many domains other than ranking of web pages. TextRank was proposed for text processing and its application to natural language processing tasks (Mihalcea & Tarau, 2004). Unsupervised algorithm TextRank was used for extracting keywords, key phrases and sentences from the documents and comparable results with supervised learning algorithms were achieved.

A weighted directed model AuthorRank for co-authors network was introduced by Liu, Bollen, Nelson, and Sompel (2005). It was used to measure the individual's author impact and popularity in the network. They showed that AuthorRank performed better as compared to degree, closeness and betweenness centrality measures.

Social tagging systems have emerged quickly on the web in which users adds tags to the resources according to their understanding of the resource materials. This user's activity of tagging resources major output is called Folksonomy. FolkRank (Hotho, Jäschke, Schmitz, & Stumme, 2006) algorithm was proposed to rank users, tags and resources on the basis of undirected links between them. It was also applied for finding communities in these social tagging systems.

Biological network analysis gained a lot of importance in the area of bioinformatics. Personalized PageRank (Ivn & Grolmusz, 2011) was proposed to analyze protein interaction networks. Important proteins are found on the basis of directed links between proteins due to different chemical reactions. The usefulness of proposed method was shown on the metabolic network data of tuberculosis bacterium as well as on blood of melanoma patients for proteomics analysis.

3.4. Social network analysis for sports teams

Cricket is a second popular sport around the world originated from Europe especially England and have its strong roots in Asia now. A few social network analysis researchers' interest is also attracted by this games popularity. (Bailey & Clarke, 2004) have investigated the inefficiencies occurred in market in player head to head betting for 2003 cricket world cup. (Bracewell & Ruggiero, 2009) have shown interest in performance monitoring of an individual batsman's performance in different matches by using a parametric control chart. (Duch, Waitzman, & Amaral, 2010) have used social network analysis based network method which was applied for quantifying individual soccer players performance. Recently an initial effort was made to apply PageRank (Page et al., 1998) to teams and captains ranking in cricket (Mukherjee, 2012). Unfortunately, they have not considered h-index based researcher indexing methods for ranking cricket teams and also ignored the number of runs and wickets parameters for both graph and non-graph based weightage methods. They also have not considered the hybridization of graph and non-graph based runs and wickets considering weightage methods.

4. Cricket teams ranking

In this section, before describing our proposed (1) Team-Index, (2) TeamRank, (3) Weighted TeamRank, and (4) Unified Weighted TeamRank methods, we briefly introduce related ICC ranking method[1] for ranking cricket teams, state of-the-art h-index (Hirsch, 2005) and PageRank algorithm (Page et al., 1998) whose variations are proposed by us for ranking cricket teams.

4.1. ICC cricket teams ranking system

The ICC employs ratings formulas for both ODI and test matches to determine a champion[1] and provide team rankings in the following way.

4.1.1. ODI matches

i. Add one point to a team for winning the match, after a series between two teams, and a half-point to each team for a draw.
ii. Score 50 points more than the opponent's rating for the winner if the gap between the two teams at the outset of the match was less than 40 points. Score 50 points fewer than the opponent's rating. In case of a tie, each team scores the opponent's rating.
iii. Score 10 points more than the stronger team's rating in a win or 90 points fewer than its rating in a loss (if the gap between teams' ratings was more than or equal to 40 points). The weaker team scores 90 points more than its rating

for a win or 10 points fewer than its rating for a loss. For ties, the stronger team scores 40 points fewer than its rating and the weaker team scores 40 points more than its rating.

iv. Add the new point totals to the existing point total for each team before the series started. Update the match numbers, as well. Throw out all points and matches that no longer fall within the last three years.
v. Divide the new points total by the new matches' total. This will provide the rating for each team, and ratings comparisons will order the teams into rankings[1].

4.1.2. Test matches

i. Add one point to a team for winning a match, after a series between two teams; add a half-point to both teams for drawing a match. Add a bonus point to the team that won the series; add a half-point to each team if the series ended in a draw.
ii. Multiply the team's series result by 50 points more than the opponent's rating, if the ratings gap between the two teams was less than 40 points at the start of the series. Then add that total to the opponent's series result multiplied by 50 points less than the opponent's rating.
iii. Multiply the stronger team's series result by 10 points more than their own rating (if the ratings gap was equal to or more than 40 points), then add that total to the opponent's series result multiplied by 90 points less than the team's own rating. The weaker team multiplies its series result by 90 points more than their own rating, and then adds that total to the opponent's series result multiplied by 10 points less than the team's rating.
iv. Add the new point's totals to the team's points total before the series began. Remove points from matches that no longer fall within the past three years. Update the number of matches by adding one more than the number of games in a series. For example, if a series lasted two matches, you would add three matches to the total.
v. Divide the updated points total by the updated match total. This represents the team's rating, and comparisons of ratings will yield the team's ranking[1].

4.2. H-index

Hirsch (2005) proposed an indexing measure used to index the scientists on the basis of her productivity in terms of papers published and citations received by her papers. The number of papers of a scientist and the number of times each of those papers are cited provides productivity and impact of his work in the scientific community. It is defined as *"A scientist has index h if h of [his/her] N_p papers have at least h citations each, and the other $(N_p - h)$ papers have at most h citations each"*. The following normalized formula can be used to calculate h-index in an easy way.

$$h = \sqrt{\frac{N_c T}{a}} \tag{1}$$

where N_cT denotes the sum of citations received by a scientist for his all papers and "a" is a proportionality constant whose value ranges between 3 and 5, usually 4 to handle the square root.

4.3. PageRank algorithm

Page et al. (1998) proposed a ranking algorithm used to rank web pages on the web named PageRank. By using this algorithm one can be aware of important web pages on the web. The intuition behind ranking web pages is very simple as if a web page is linked by many other web pages and the pages providing inlinks are themselves important then the page is important. The rank of all the pages (nodes) in a web pages network can be calculated by using the following formula.

$$PR(A) = \frac{(1 - \mathrm{d})}{N} + d\left[\frac{PR(T_i)}{CT_i} + \ldots + \frac{PR(T_n)}{CT_n}\right] \tag{2}$$

where $PR(A)$ is PageRank of A, $PR(T_i)$ are PageRanks of pages which are providing the links to page A, CT_i is the number of outlinks given by page T_i to other web pages in the network, N is the total number of pages and d is the damping factor, whose value usually used in literature is 0.85.

4.4. Team-index (t-index)

Our first proposed method t-index is an adoption of h-index (Hirsch, 2005). H-index is considered as one of the most used scientific productivity indexing or ranking method in co-author networks. In t-index like h-index teams are referred to as author's and papers as number of runs and wickets from which matches are won by the team. The idea is that if a team wins matches from more number of runs and wickets the higher the t-index the team will have.

We take an example of a team A which played 15 matches in total from which 7 matches are won by runs and 8 matches are won by wickets. Tables 1a and 1b for team A are used to calculate its t-index as follows.

Table 1a
Matches won from wickets.

T1	
No. of matches	No. of wickets
1	10
2	9
3	8
4	8
5	7
6	2
7	3
8	1
Total	48

Table 1b
Matches won from runs.

T2	
No. of matches	No. of runs
1	138
2	99
3	86
4	84
5	52
6	6
7	5
Total	470

$$\text{T-Index} = \frac{\sqrt{\text{T1} + \text{T2}}}{2} = \frac{\sqrt{3.46 + 10.83}}{2} = \frac{14.88}{2} = 7.14 \tag{3}$$

$$\text{T1} = \frac{\sqrt{\text{Total no. of wickets}}}{2} = \frac{\sqrt{48}}{2} = \frac{6.928}{2} = 3.46$$

$$\text{T2} = \frac{\sqrt{\text{Total no. of runs}}}{2} = \frac{\sqrt{470}}{2} = \frac{21.68}{2} = 10.83$$

4.5. TeamRank (TR)

Our second proposed method TR is an adoption of page rank algorithm. PageRank (Page et al., 1998) is considered as one of the most important graph based page ranking algorithms on the web. TR of a team should be high if the team wins many matches from other teams and those teams are strong (those teams also had won many matches from stronger teams). TR is calculated by using the following formula.

$$TR(A) = \frac{(1 - \mathrm{d})}{N} + d\left[\frac{TR(T_i)}{C(T_i)} + \ldots + \frac{TR(T_n)}{C(T_n)}\right] \tag{4}$$

where, $TR(A)$ is the TeamRank of Team A, $TR(T_i)$ is the TeamRank of Teams T_i which link (lose matches) to Team A, $C(T_i)$ is the number of outlinks (matches lost) by team T_i, d is a damping factor which can be set between 0 and 1, N is total number of teams

Here, inlinks refer to the matches won say a team has won 10 matches then inlinks will be 10 and outlinks refer to the matches lost from another team say a team lost 14 matches then outlinks will be 14.

4.6. Weighted TeamRank (WTR)

Our third proposed method is a weight based enhancement in TR. It assigns larger rank values to stronger teams instead of dividing the rank value of a team evenly among it is outlink matches. Instead of only considering the number of matches we do in TR we also consider the number of runs and wickets from which the matches are lost. The idea is that if a team lost matches from more runs and wickets will contribute less to the rank of the team being ranked.

An example is provided to show how the parameter of runs and wickets impact the ranking of teams. Suppose we have two teams A and B with same number of lost matches 10. If the sum of the runs from which team A lost those 10 matches is

Table 2a
TeamRank scores contribution when runs and wickets are ignored.

Team A	Team B
$\frac{1}{10} = 0.1$	$\frac{1}{10} = 0.1$

Table 2b
TR scores contribution when runs and wickets are considered.

Team A	Team B
$\frac{1}{\frac{60(10)+20(200)+20(30)}{60+200+30}} = 0.056$	$\frac{1}{\frac{60(10)+20(100)+20(15)}{60+100+15}} = 0.061$

200 and sum of the wickets is 30 and the sum of the runs from which team B lost those matches is 100 and sum of the wickets is 15. It will have different rank scores of teams. As in the following example we can see that when both Team A and B has lost same number of matches they have same scores 0.1 while contributing to some other teams from which they have lost matches. But when runs and wickets are considered we can see that Team A has rank score of 0.056 while Team B has rank score 0.061 which is higher as compared to Team A. We can see that team has lost matches from more runs or wickets as compares to Team B, as Team A's lost matches runs sum is 200 and sum of wickets is 30 while Team B's lost matches runs sum is 100 and sum of wickets is 15. Finally we can say that if a team's loses matches from more runs and wickets it contributes less score to the team from which the team has lost matches (see Tables 2a and 2b).

WTR is calculated by using the following formula.

$$WTR(A) = \frac{(1 - d)}{N} + d\left[\frac{WTR(T_i)}{WC(T_i)} + \ldots + \frac{WTR(T_n)}{WC(T_n)}\right] \tag{5}$$

where WTR(A) is the weighted TeamRank of Team A, WTR(Ti) is the TeamRank of Teams Ti which link (lose matches) to Team A, WC(Ti) is the number of outlinks (matches lost) by team Ti, in order to calculate WC(Ti) (weighted outlinks) we use weighted arithmetic mean formula, d is a damping factor which can be set between 0 and 1, N is total number of teams

$$\text{Weighted Outlinks} = \frac{60(\text{matches}) + 20(\text{runs}) + 20(\text{wickets})}{\text{matches} + \text{runs} + \text{wickets}} \tag{6}$$

One can try different weights for matches, runs and wickets such as (50(matches), 25(runs), 25(wickets)) or (40(matches), 30(runs), 30(wickets)). We used 60% weightage for match result as it is important to win or lose as compared to number of runs or wickets whose weightage is 20% and 20%, respectively used in this work.

4.7. Unified weighted TeamRank (UWTR)

Our proposed fourth method UWTR is hybridization of t-index and WTR methods. UWTR combines the power of a team in terms of winning number of matches in terms of runs and wickets without considering graph weightage (t-index) and power of a team in terms of the power of the teams from which those matches are won with considering graph weightage. UWTR is calculated by using the following formula.

$$\text{UWTR} = \frac{(1 - d)}{N}\left(\frac{WT_j}{\sum_{t=1}^{N} WT_i}\right) + d\left[\frac{WTR(T_i)}{WC(T_i)} + \ldots + \frac{WTR(T_n)}{WC(T_n)}\right] \tag{7}$$

where WT_j is the t-index of the team for which we are calculating the rank, $\sum_{t=1}^{N} WT_i$ is the sum of t-index of all teams.

5. Experiments

This section provides the details of the cricinfo dataset used followed by the results and discussion about the ranked cricket teams of both ODI and test matches. Later in this section, effect of damping factor on ranking results for our proposed methods is also studied.

5.1. Dataset

The dataset for experiments is taken from the cricinfo web site[2] from January 2000 to March 2012 and ICC cricket rankings point system of ODI and test matches is taken as existing method. There are ten teams which has been given the test status by ICC. Teams are categorized into strong and weak teams on the basis of opinions about their performance of cricket experts.

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

Table 3
Teams ranking WRT ODIS.

ICC ranking	Team	Matches	Points	Rating
1	Australia	49	6030	123
2	South Africa	30	3549	118
3	India	55	6409	117
4	England	40	4469	112
5	Sri Lanka	55	6111	111
6	Pakistan	48	4989	104
7	New Zealand	31	2667	86
8	West Indies	33	2814	85
9	Bangladesh	36	2408	67
10	Zimbabwe	33	1511	46

T-index		TR		WTR		UWTR	
Australia	3.80789	Australia	0.133857	South Africa	0.0512701	Australia	0.00630054
South Africa	3.53553	India	0.121694	Sri Lanka	0.0512691	South Africa	0.00586111
Sri Lanka	3.53550	Pakistan	0.119422	Australia	0.0512602	Sri Lanka	0.00586098
Pakistan	3.4641	Sri Lanka	0.11424	India	0.0512553	Pakistan	0.00573821
India	3.3541	South Africa	0.110733	New Zealand	0.0512466	India	0.00556624
New Zealand	3.08221	New Zealand	0.0981	England	0.0512424	New Zealand	0.00512497
England	2.95804	England	0.0946053	Pakistan	0.051204	England	0.00492394
West Indies	2.78388	West Indies	0.081723	West Indies	0.0511923	West Indies	0.00463663
Bangladesh	2.17945	Zimbabwe	0.0636812	Bangladesh	0.0509535	Bangladesh	0.00363257
Zimbabwe	2.12132	Bangladesh	0.0619443	Zimbabwe	0.0508243	Zimbabwe	0.00352188

The results of our proposed methods are subjectively compared with the existing ICC rankings to show their effectiveness. The subjective discussions are performed with the help of several cricket team players of our university and different cricket club team players of Islamabad and Faisalabad.

Strong teams: Australia, India, Pakistan, South Africa, Sri Lanka, West Indies, England, New Zealand.
Weak teams: Zimbabwe, Bangladesh.

5.2. Results and discussions

5.2.1. One day international matches

ODI team's rankings are provided in Table 3. T-index is used to rank teams by considering the number of runs and wickets from which the teams have won matches. The top 3 teams ranked by ICC ranking are Australia, South Africa and India, respectively. The top ranked team for t-index is also Australia with clear difference of score in comparison to other teams at number 2 and 3, which is same as ICC cricket ranking. The second team ranked is South Africa which is same as ICC team rankings. But the team at third no is Sri Lanka which is not same as ICC team rankings. The Indian team is ranked 5th by t-index due to winning from less number of runs and wickets from other teams as compared to Sri Lanka which have won matches from more wickets and runs as compared to India so is ranked 3rd.

Australia again stands first by our second method TR, which is same position given in ICC rankings. But by point system India is ranked 3rd while by TR method India is ranked at number 2nd. By analyzing data we have found that Indian team has won more matches against strong teams like Australia, Pakistan, South Africa and Sri Lanka as compared to South Africa. So the inlinks weights by winning from stronger teams are more for India as compared to South Africa. Pakistan and Sri Lanka are also ranked higher by TR as compared to South Africa due to their most winnings from stronger teams.

By applying our proposed third WTR method we got different results as from TR method. By this method South Africa ranked first, Sri Lanka is second and Australia is ranked third because we are calculating weight-age of each team against other team by considering number of runs and wickets from which matches are won. South Africa has won more matches from weaker teams resulted in winning matches from large number of runs and wickets so is ranked number one.

As UWTR is the combination of two techniques which are t-index and WTR, for ODI matches Australia hold first position, South Africa and Sri Lanka on second and third and so on. One can see that rankings provided by t-index and UWTR are same for all teams which shows that considering runs and wickets are both useful though similar results are obtained when graph based strength or weakness of teams is considered. For our proposed all methods England team is ranked 6th or 7th due to winning from less runs and wickets.

5.2.2. Test matches

Test team's rankings are provided in Table 4. T-index is used to rank test teams by considering the number of runs and wickets from which the teams have won matches. The top 3 teams ranked by ICC ranking are England, South Africa and Australia, respectively. The top ranked teams ranked by t-index are Australia, England and Sri Lanka in which Australia with

Table 4
Teams ranking WRT tests.

ICC ranking – test match	Team	Matches	Points	Rating
1	England	48	5614	117
2	South Africa	32	3709	116
3	Australia	46	5153	112
4	India	46	5103	111
5	Pakistan	35	3781	108
6	Sri Lanka	38	3780	99
7	West Indies	38	3212	85
8	New Zealand	28	2366	85
9	Bangladesh	18	135	8

T-index		TR		WTR		UWTR	
Australia	3.7081	Australia	0.158223	India	0.0515155	Australia	0.00692822
England	3.31662	England	0.136533	England	0.0515	England	0.0062163
Sri Lanka	3.20156	South Africa	0.122923	Australia	0.0514915	Sri Lanka	0.00598051
Pakistan	3	India	0.11662	South Africa	0.0514199	Pakistan	0.0056282
India	2.95804	Sri Lanka	0.0968203	Pakistan	0.0514129	India	0.00556456
South Africa	2.95804	Pakistan	0.0959763	New Zealand	0.0513838	South Africa	0.00555422
New Zealand	2.69258	New Zealand	0.08725	Sri Lanka	0.0513102	New Zealand	0.00506361
West Indies	2.34521	West Indies	0.0746774	West Indies	0.0511389	West Indies	0.00440602
Zimbabwe	1.65831	Zimbabwe	0.0587397	Zimbabwe	0.0503121	Zimbabwe	0.00305885
Bangladesh	1.5	Bangladesh	0.0522367	Bangladesh	0.0502923	Bangladesh	0.00276505

clear difference of score in comparison to teams at 2nd and 3rd number, which is different from ICC cricket rankings in which England is ranked number 1. The south African team is ranked 6th by t-index due to winning from less number of runs and wickets from other teams as compared to Sri Lanka which have won matches from more wickets and runs as compared to South Africa so is ranked 3rd.

Australia again stands first by our second method TR, which is different from ICC rankings in which England is ranked first. But by point system South Africa is ranked 2nd while by TR method South Africa is ranked at number 6 and Sri Lanka is ranked at number 3. The data analysis explains that Sri Lanka team has won more matches against strong teams like Australia, India, Pakistan and South Africa as compared to South Africa. Even Indian and Pakistani team is ranked higher due to winning matches from strong teams. So the in link weights by winning from stronger teams are more for Australia and Sri Lanka as compared to South Africa.

By applying our proposed third WTR method we get different results as from TR and WTR results for ODI matches. By this method India is ranked first, England is ranked second and Australia is ranked third because we are calculating weight-age of each team against other team by considering number of runs and wickets from which matches are won. India has won more matches from weaker teams resulted in winning matches from large number of runs and wickets so is ranked number one.

As UWTR is the combination of two techniques which are t-index and WTR, for test matches Australia holds first position, England and Sri Lanka on second and third, respectively and so on. One can see that rankings provided by t-index and UWTR are same for all teams which shows that considering runs and wickets are both useful though similar results are obtained when graph based strength or weakness of teams is considered. For our proposed all methods Australian team is ranked number one for both ODI and Test matches due to winning from more runs and wickets as well as from stronger teams. The results for WTR method are a bit different though in which other teams are ranked on top.

5.3. Effect of damping factor on teams ranking

Parameter d is used in our three proposed methods TR, WTR and UWTR. As d is the dampening actor which is used to normalize values usually ranges from 0.1 to 0.9. The effect of damping factor on teams' rankings in one day and test matches is discussed in the following section.

5.3.1. ODI matches

Effect of parameter d on TR for ODI matches is shown in Fig. 1. It is observed that for smallest value of $d = 0.1$ all the teams have less variation among their scores. But with the increase in the value of d the score of top ranked team increases, the score of mediocre teams remains stable while the score of low ranked teams decreases. As a whole we can see that with the increasing value of d the difference of scores of teams is increased and better distinguishable rankings are obtained and the ranking of teams remains almost same for different values of d. Effect of parameter d on WTR for ODI matches is shown in Fig. 2. It is observed that with the increasing value of d the rank scores of teams decreases, which is totally a different behavior from the effect of d on TR where number of runs and wickets are not considered. It is also seen that the difference between rank scores of teams is less and the overall ranking of teams remains almost same for different values of d. Effect of parameter d on UWTR for ODI matches is shown in Fig. 3. It is observed that with the increasing value of d the

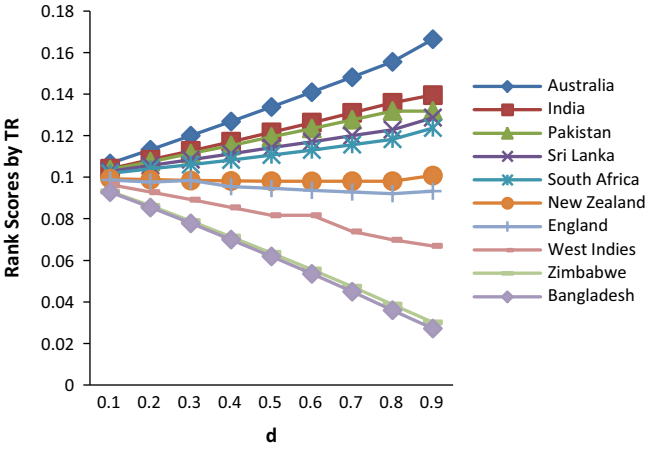

Fig. 1. Effect of *d* on TR in ODI matches.

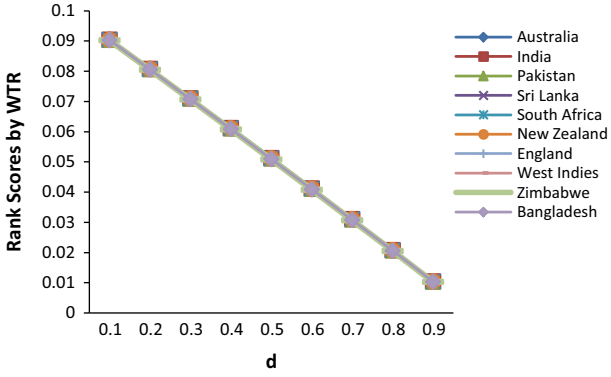

Fig. 2. Effect of *d* on WTR in ODI matches.

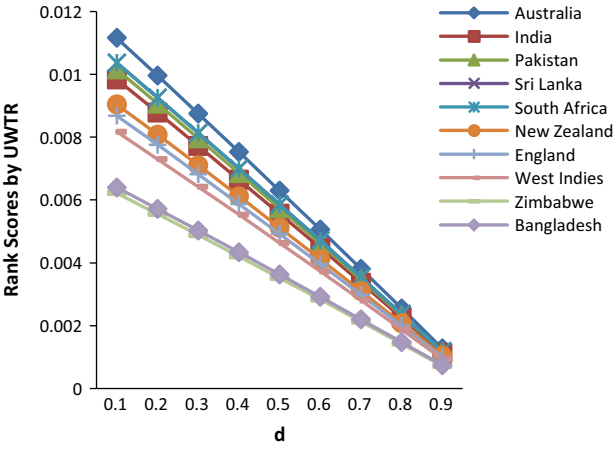

Fig. 3. Effect of *d* on UWTR in ODI matches.

rank scores of teams decreases, which is a similar behavior with WTR. It is also seen that the difference between rank scores of teams are higher when value of *d* which is inverse of *d* effect in TR, while with the increase in the value of *d* the rank scores difference decreases which is also similar to WTR behavior in which the rank scores difference for all *d* values is less and the overall ranking of teams remains almost same for different values of *d*.

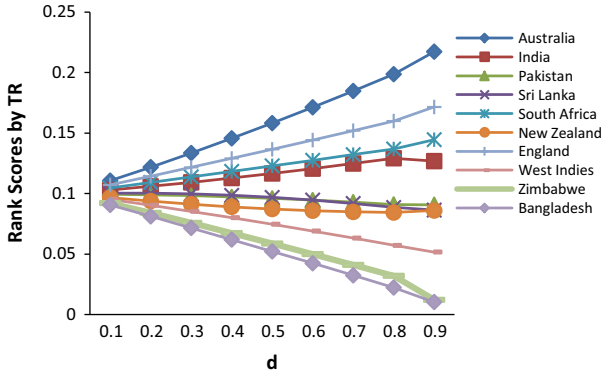

Fig. 4. Effect of *d* on TR in test matches.

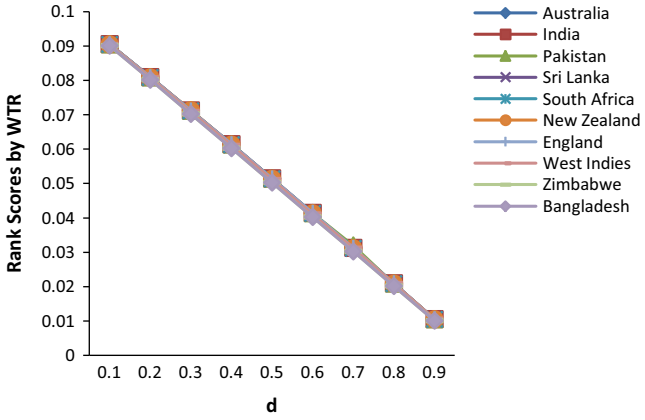

Fig. 5. Effect of *d* on WTR in test matches.

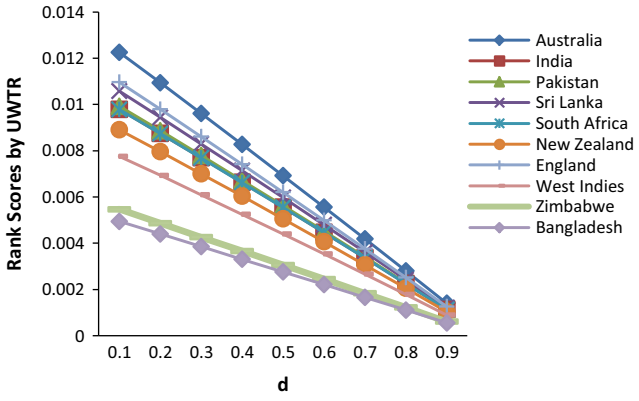

Fig. 6. Effect of *d* on UWTR in test matches.

5.3.2. Test matches

Effect of parameter *d* on TR, WTR and UWTR for test matches is shown in Fig. 4–6, respectively. The results for the affect of damping factor *d* on test matches for TR, WTR, and UWTR are similar to the results of the affect of *d* on TR, WTR, and UWTR respectively for ODI matches.

6. Conclusions

This paper is about different graph and non graph weightage based ranking algorithms for cricket teams' rankings. It is found that number of runs and wickets from which team wins are important and affect teams ranking. The weightage factor

is also important when two teams' win similar number of matches from similar kind of opponents. The hybridization of h-index and PageRank based methods for ranking cricket teams is also effective as it considers graph, non graph weightage as well as number of runs and wickets for both. It is also concluded that the effect of different values of d on the proposed methods performance is significant. As for ODI matches ranking for TR method the higher value of d is suitable to make rankings scores of teams more distinguishable, for WTR all values of d have same impact and for UWTR lesser value of d is suitable to make rankings scores of teams more distinguishable which is inverse of d's effect on TR. Damping factor d has similar affect on TR, WTR and UWTR methods when they are used for ranking teams for test matches.

In future, we plan to propose the variations of our proposed methods of teams ranking for ranking players of teams such as bowlers and batsman's. Time Weighted PageRank (Manaskasemsak et al., 2011) can also be adopted for ranking teams by considering temporal dimension.

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