COMPARISON ANALYSIS OF REQUIREMENT PRIORITIZATION METHODS BETWEEN CASE BASED RANKING AND CUMULATIVE VOTING

Harunur Rosyid, Eko Prasetyo, Andy Hidayat Jatmika, dan Daniel O. Siahaan
Program Studi Teknik Informatika, Universitas Muhammadiyah Gresik.
Fakultas Teknologi Informasi, Institut Teknologi Sepuluh Nopember Surabaya.
harun.ac@gmail.com, eko1979@yahoo.com, mail4_andy@yahoo.com, dan daniel@if.its.ac.id

ABSTRACT
The selection of requirements among a number of requirements is an important activity in software development. Mistake in arranging priority can result in that the software is rejected by user because of the lack of standard, and eventually the project can be declared fail. A number of methods can be used to rank requirements. AHP, CBR, CV, VOP, and NA are some requirement ranking methods that can be used. Factors that are required for selecting method are time consumption, quality, and complexity. In this paper, a comparison analysis between CBR and CV in regards to the above three factors is elaborated. The analysis result is hoped to be able to help the decision makers in providing explanation references about the compared two methods.

Keywords: Requirement Prioritization, Case-Based Ranking, Cumulative Voting, Comparison Analysis.

1. Introduction
Requirements are one matter of several activities that must be done in software development phase. Requirements appearing in software development can be many. There are many deliberations/constraints that must be considered in determining requirements priorities, before making decisions. Several constraints that must be considered including importance; penalty; cost; financial benefit; strategic benefit. Requirements method used to determine requirements ranking will be used later as reference for developer to arrange requirements priorities. The process of determining requirements and selection ranking needs more resources. Following the study by NASA, requirements phases need 7% up to 15% of all resources in the project, while COCOMO reports around 8% is used for consumption in the requirements phase.

Many researches have produced methods for requirements prioritization, such as: Analytic Hierarchy Process (AHP), Value-Oriented Prioritization (VOP), Case-Based Label Ranking (CBR), Cumulative Voting (CV), and Numerical Assignment (NA). Each method uses technique to support the determination of requirements rank. AHP and CV method use ratio scale in finding rank. CBR uses iteration model rank with an optimal calculation in the learning process while also minimizing error, while NA method uses ordinal scale.

From the work process, the AHP method shows an accurate ranking result in giving evaluated requirements preference, while CV shows a very fast performance in giving result in every requirements. The similarity characteristics in this calculation indicates that these methods may be comparable with different design of work steps.

Because of the important of requirements to be prioritized, it is necessary to conduct a comparison study of requirements rank. Error in fulfilling requirements of a developed software can have consequences that the software can not be accepted by user, even the software is finished on time. It is a big cost if requirements implemented in the software are not in line with those expected by user.

This paper is divided in to 6 sections, section 1 elaborates upon the identification of requirements, requirements rank and several methods for ranking activity, section 2 elaborates upon several articles related to kernel presented in this paper, section 3 elaborates upon the work of rank methods that is mainly investigated in this paper, section 4 contains parameters measured in comparing methods, section 5 elaborates upon the analysis of each method with the parameters mentioned in section 4, section 6 contains conclusion taken from method analysis result.

2. Related Work
Articles discussing the comparison of several methods, such as Patrik Berander article show that the methods compare requirements in terms of scale, granularity, and sophistication. Anna Perini conducted methods comparison between AHP and CBR, which focuses on time-consumptions, easiness level, and result quality. Each article presents to benefits and defects of each method discussed.

This paper discusses method comparison of analysis requirements rank which focuses on the Case Based Ranking (CBR) method and Cumulative Voting (CV) method. Both methods are the same in using ratio scale within the process. They only differ in the steps of counting ranking. Although Anna Perini concluded that CBR method is in fast category, but
when it compared to AHP, CBR can be said to have little time consumption, while CV, following Patrik Berander\cite{11} result, is a complex method but resulting a better result when compared to the Numerical Assign method.

3. Prioritization Method

This section will explain the methods of prioritization analysed in this paper.

3.1 Case Based Rangking

The Case-Based Ranking (CBRank) method\cite{8,5,17} exploits machine learning techniques to guide user preferences elicitation in the prioritization process. The framework rests on an iterative process that can handle single and multiple decision makers (stakeholders) and different criteria (both business goals and technical parameters).

Figure 1A sketches the basic steps of the prioritization process, where manual elicitation interleaves with machine supported steps. The main input to the process is the collection of requirements that have to be ranked. The final output of the process is an approximation of the target ranking. The pair sampling activity is an automatic procedure which selects a pair (or a sample of pairs) of requirements on the basis of a predefined selection policy which may take into account information on the currently available rankings.

The user performs the evaluation of the requirements pairs, by iterating the following steps till all the pairs in the sample have been evaluated: select a pair from the sample; evaluate the relative importance of the requirements in the pair. That is, given a pair of requirements A and B, the user is asked to specify what is the ‘most important’ requirements among A and B with respect to the given criterion. Differently from AHP, there is no range of values, and the preference is strict. The output of this step is a set of ordered pairs.

The ranking learning activity takes in input the stakeholder preferences acquired in the previous step, and computes an approximation of the ranking function. The learning procedure is based on the boosting approach described in\cite{19} and may eventually exploit also available knowledge on the requirements rankings induced by other prioritization criteria (e.g. the cost for the realization of the requirements, the estimated utility) defined on the initial set of requirements in order to best approximate the final ranking.

If the ranking produced by the ranking learning activity can be considered a good approximation (e.g. the error measures exploited in the method are minimized), it will be given in output, otherwise it may become the input to a further iteration of the process.

The CBRank method is supported by a web-based tool named SCORE (Supporting Case-based Oriented Rank Elicitation)\cite{10} which allows for a distributed use of the framework, to support the pair-wise priority elicitation by distributed stakeholders. Figure 2 shows a snapshot of the SCORE graphical user interface.

The system supports the whole evaluation process. In particular, SCORE presents the user an agenda of comparisons. The user can analyze each one of the pairs specifying the preferred requirements in the pairs, by indicating which one of the requirements is ‘the most important’ (see the system user interface showed in Figure 2). Finally, once all the evaluations have been performed, the system computes the rank and, in the case of a further iteration, it presents to the user the set of new pairs of requirements to be evaluated.

3.2 Cumulative Voting

Technique that produces ratio-scale results is the Cumulative Voting technique (also known as the Hundred-Dollar Test), further on denoted as CV\cite{6}. This technique has been used for a long time within other fields, such as political elections and elections for company boards\cite{11}. In the software engineering domain, CV has not been reported in as many cases as AHP, even though the number of reported cases has grown in the last years, for example in requirements prioritization\cite{12} and in prioritization of process improvements\cite{13}. CV is considered as a simple and straightforward technique where the stakeholders are given 100 imaginary units (money, points, etc.) to distribute among the objects to prioritize\cite{6}. In requirements prioritization, the number of units assigned to a requirement represents requirement’s relative priority (e.g. importance, cost, risk) in relation to the other requirements. Since the requirements are assigned numbers in this way, it is possible for a stakeholder to give a requirements zero in priority. This is not possible in AHP since all requirements take part in pair-wise comparisons, meaning that a requirement always gets some amount of importance. Figure 1B sketches the basic steps of the prioritization process for this method, where manual elicitation interleaves with machine supported steps.

A problem with CV arises when there are too many requirements to prioritize. For example, if you have 25 requirements, there are on average four points to distribute for each requirement. Regnell et al. faced this problem when there were 17 groups of requirements to prioritize\cite{12}. In the study, they used a fictitious amount of $100,000 to have more freedom in the prioritizations. The subjects in the study were positive about the technique, indicating the possibility to use amounts other than 100 units (e.g. 1,000; 10,000; or 100,000). Another possible problem with CV (especially when there are many
requirements) is that the person performing the prioritization miscalculates and the sum do not add up to the prescribed amount of points\textsuperscript{[14]}. This can be prevented by using a tool that informs about how many points that are left to distribute.

![Diagram of the CBR (A) and CV (B) Prioritization Process’s Steps.](image)

Figure 1. The CBR (A) and CV (B) Prioritization Process’s Steps. The Steps Depicted in the Left Part of the Scheme are Automated in Their Respective Tools.

![Table: SCORE - Single User: Supporting Case-Based Oriented Rank Elicitation](image)

**SCORE - Single User**

Supporting Case-Based Oriented Rank Elicitation

<table>
<thead>
<tr>
<th>Requirement A</th>
<th>Rank</th>
<th>Requirement B</th>
</tr>
</thead>
<tbody>
<tr>
<td>R7</td>
<td>Identifier</td>
<td>R13</td>
</tr>
<tr>
<td>Inserting and deleting a song in/from a compilation</td>
<td>Description</td>
<td>List of the top 10 downloaded compilations</td>
</tr>
</tbody>
</table>

More important requirement

More important requirement

*Attention: after the pair elicitation, it is not possible to change the preference.*

Figure 2. GUI Snapshot. A Snapshot of the Graphical User Interface Showing the Pair of Requirements (R7 and R13) Under Evaluation in SCORE.

One should only perform the prioritization once on the same set of requirements, since the stakeholders might bias their evaluation the second time around if they do not get one of their favorite requirements as a top priority. In such a situation, stakeholders could put all their money on one requirement, which might influence the result heavily. Similarly, some clever stakeholders might put all their money on a favorite requirements that others do not prioritize as highly (e.g. Mac compatibility) while not giving money to requirements that will get much money anyway (e.g. response time). One solution is to limit the amount spent on individual requirements\textsuperscript{[6]}. However, the risk with such an approach is that stakeholders may be forced to not prioritize according to their actual priorities.
4. Measuring Method Properties
To do effective comparison analysis, it is necessary to determine parameters that will be evaluated during the analysis. Parameters used in this comparison analysis are time-consumption, second parameter is also very essential which is the process result of quality rank. Complex process that must be run in the process of prioritization also can be influential towards the long prioritization process.

4.1 Time-Consumption
The time-consumption[2] of a prioritization process is defined as the time interval between the time to get the final ranking (end time of the prioritization task) and the time the user starts prioritizing (start time of the prioritization task). This time measure results from the sum of the times spent in each step of the prioritization process sketched in Figure 1. In practice the most time-consuming step is the give preference step, which is repeatedly performed by a method’s user like CBR method. At CV method, user must decide to distribute among all requirements. Time-consumption can be measured by asking the subjects to annotate the start and end times of prioritization tasks (we call it declared time). In the case of tool-supported methods, the start and end times can be recorded by the tool and the difference is computed automatically (actual time).

4.2 Result Quality
Rank accuracy[2] can be defined as the measure of how much the ranking is computed, while using a given prioritization approach, it is close to the ideal target ranking. In the case of requirements, the ideal target ranking, is usually not known a priori. We may define it as (definition 1) the ranking the decision maker has in mind based upon some implicit considerations, or as (definition 2) the result of a negotiation process among several decision makers.

4.3 Complexity
Complexity is difficulty level in running a method. Evaluation about complexity very subjective, depending on who runs the process. A method can be assumed complex by one who not yet absolutely know or newly knows the methods, but after several times running the method, it will turn to be easy because they are accustomed to the running. In this paper, size for complexity will estimate all possibility of objective concepted during running the method.

5. Analysis of Method
This section explain CBR and CV methods analysed in each parameters with a consideration of all possibility to happen during process prioritization in each method. In CBR method, possibility that can happen during prioritization process:
1. Stakeholder must do election one of the pair on the preferential to be prioritized. At the time of election, stakeholder can give different answer for the same question that is repeated asked. That can be corrected by stakeholder.
2. Although number of pair requirements that must be evaluated by stakeholder not as much as AHP, but human natural inclination can be bored, when it has to be done repeatedly.
3. The existence of preference acquisition policy[17] that gives rule hits pair must be evaluated beforehand in every given step preferential. This matter can cause several pairs requirements that will be asked repeatedly.

In CV method, possibility that can happen during prioritization process:
1. Because model kernel that is used in this method is a voice distribution to every requirement, it is possible that requirements will not get voices.
2. The worst case in this method is that it is still possible that a stakeholder will give all the voices to one requirement.
3. Subjective elements still greatly influence stakeholder when distributing voices, because stakeholder deals with all requirements at the same time. This matter is in contrast with CBR, because in CBR stakeholder deals only with 2 requirements at the same time.

5.1 Time-Consumption Analysis
Time consumption used in CBR method changes at the time of preference process. Analysis by Anna Peruni[2] that compares AHP to CBR for 20 requirements, results in an average time of 38.65 second to AHP and 10.78 second to CBR. If this number is raised 3 fold times to become 60 requirements, time difference between AHP and CBR approximately 19 second.

Time consumption required in CV method is used by stakeholder when conducting deliberation of voices for the requirements. While Patrik Berander[1] concludes that CV is easier and quicker in the process, and look more scalable and better in a number of criteria. The number of requirements investigated in the article are 58 requirements. It has shown that AHP consumes far more times compared to CV.

Analysis result shows that, if the number of requirements are 58 up to 60, AHP is taking longer than CBR. It can be considered that for CBR, time consumption is more than CV.
5.2 Result Quality Analysis

Anna Perini[5] concludes that the accuracy problem between AHP and CBR is not suitable, since it results in 0.001, where the result of 0.09 expected. This matter is very influential in the preference process, where CBR is only evaluate one pair of requirements in every iteration preferency, while in AHP, stakeholder must evaluate every pair of 2 requirements. It is concluded that AHP is more accurate than CBR.

Thesis of Patrik Perander[1] explains that for CV, in the case of 58 requirements, stakeholder only distributes the voice in an average of 34% from all requirements, while for 17 requirements, stakeholder distributes the voice of 53% from all requirements. This matter indicates that it is possible that there are requirements which will not get any voices, although for total requirements, Big[12] can help to enlarge points/voices total held by stakeholder. But this matter causes that the result requirements given by limited partnership is still less accurate. Other problem is when there are 2 requirements which have not get voices and that happens at all of contributed stakeholders in the process of prioritization, so there are 2 methods occupied the same ranking in the position.

It can be seen from the analysis, in terms of result quality of prioritization problem, CBR method can not be said better compared to CV, and vice versa. This matter is very clear because in CV there are possibility of requirements are not looked by stakeholder. While in CBR, stakeholder will come to each requirement at least once. Other existing weakness in CBR is that it only gives results from single stakeholder, while CV can come from multi stakeholder. For this problem, it is necessary to do further study to make a comparison conclusion in terms of result quality side rank for CBR and CV methods.

5.3 Complexity Analysis

Method complexity can be seen from this steps of methods, specifically the number of existing iterations. The iteration number and manner counts is also influenced by the number of requirements. The logic is if the number is ever greater and total steps ever greater, for polynomial quantifying, it is also more complex when the number of requirements are ever greater.

In CBR method, there are 2 iterations, preference iteration step and returning iteration when the result ranking is not yet maximal. Calculation process learning that is used in CBR method is more complex when total requirements are ever greater.

In CV method, there is only one iteration which waits all stakeholders to put in the voice distribution result. Calculation accumulates all stakeholder voices to each requirement. From the complexity side, it can be declared that CBR method is more complex than CV. Table 1 shows comparison result of collection of 2 methods.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Case Based Ranking</th>
<th>Cumulative Voting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-Consumption</td>
<td>more</td>
<td>less</td>
</tr>
<tr>
<td>Result Quality</td>
<td>can not be decided yet</td>
<td>can not be decided yet</td>
</tr>
<tr>
<td>Complexity</td>
<td>more complex</td>
<td>simpler</td>
</tr>
</tbody>
</table>

6. Conclusion

This paper described an analysis study aimed at comparing two tool-supported requirements prioritization methods, CBR and CV.

Parameters evaluated in this comparison are 3 parameters. These are: time consumption, result quality, and complexity. Based on several principal references[1, 2, 4, 5] evaluation can be done in terms of where is the method requirements prioritization to be used. This matter helps decision makers to give suggestion and opinion based on the result given in this paper. Result obtained from this comparison analysis study is that CBR is longer in the process of prioritization compared to CV. In terms of result quality problem it still can not be decided yet which one is better because it still needs further study, while in the case of complexity, CV is simpler that in CBR.

CBR method is the only method that uses learning process in the ranking calculation. It is still necessary to study further by comparing it to other methods like Value-Oriented Prioritization (VOP)4, Numerical Assignment (NA)3, Quantitative Win Win or others.

References


