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# Analysis of models for software reliability

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**Abstract:** Software efficiency indicators play a key role in its optimization. Various ways are available to ensure software optimization. One of the key indicators of software is its reliability. Reliability of software (SR) is the features of the features to accomplish certain functions, and they are kept in certain boundaries under definite circumstances. Non-denial and recoverability of software define its reliability. In article Software reliability models show the form of a random process, as it periodically determines the behavior of software failures. The article uses the VIKOR (VIsekriterijumska optimizacija i KOmpromisno Resenje) method for the development of an algorithm to increase software reliability. The VIKOR method is used for different areas. Some sources provide information on the application of the VIKOR method. This method is developed for a multi-criteria decision making or analysis of multi-criteria decision. The alternatives here are ranked and the one closest to the so-called ideal compromise is determined. As a result of the author's research, six important criteria for software reliability are identified and alternatives are used. The fuzzy VIKOR method is used for multi-criteria evaluation of software. The work done is considered to be novel, and the advantage is that the selected criteria have not yet been used for this type of task, which positively changes its efficiency. The experiments perform positive results.

**Keywords:** Characteristics, Criteria, Efficiency, Optimization, Software, VIKOR method

## Introduction

Various technologies and methods are applied when developing high quality software systems. Different ways are available for creating optimal software. In previous articles (Mahmudova, 2020), an algorithm was developed to select the best software using the TOPSIS [5] and AHP methods [6] to optimize the software, and good outcomes are obtained as a result of experiments. Software efficiency (SE) (ISO / IEC standard 25010: 2011 (state standard R ISO / MEK 25010-2015) determines the quality model of the product, and eight top-level characteristics are as follows.

The efficiency characteristics of software are:

1. Functionality;
2. Productivity;
3. Compliance;
4. Ease of use;
5. Reliability;
6. Security;
7. Accompanying;
8. Mobility.

As noted, reliability is one of the key performance characteristics of software. Reliability of software (SR) is the features of the features to accomplish certain functions, and they are kept in certain boundaries under definite

circumstances. In other words, the reliability of a program is the probability that software will work without any failure for a certain period of time. The reliability of the software is determined by its non-denial and recoverability [8]. There may be important factors that affect the reliability of software. The reliability of software is its ability to maintain its functioning in the course of data processing on computer.

Software reliability criteria:

1. Software accuracy;
2. Software recovery;
3. Improvement;
4. Algorithm selection;
5. Software reserve;
6. Software monitoring and testing.

Software accuracy refers to its compliance with the specifications. One of the important features of software reliability is that it can be restored due to errors and consequences in the program. Recovery after a software failure is the ability to correct the program text, correct the data, and make changes to the organization of the computation process. The recovery capability of software can be assessed by the average time it takes to troubleshoot a program and restore it to working condition. Software recovery depends on several factors: the complexity of the structure of software complex, the algorithmic language in which software is developed, the style of programming, the quality of software documents, and so on. Causes of software failure and the main causes of direct software failure lie in tie followings:

1. errors hidden in software itself;
2. falsification of used input data;
3. user error;
4. device failure on which the computing process is performed.

The American National Standards Institute (ANSI) defines the reliability of software as: the probability that a program will run flawlessly over a period of time in a given environment. It is difficult to get the reliability of the program, because the high complexity of the program does not allow it. The following information should be considered to improve the reliability of software:

- Computer's configuration;
- Performance and reliability, for example, how software responses when a button is pressed, how many problems it encounters while software is running, how fast the data is sent over the network;
- Most commonly used tools in software program.

The development of an algorithm for software reliability is one of the foremost issues. There are three main types of algorithms used to solve different types of problems on a computer:

- Linear algorithms;
- Branching algorithms;
- Periodic algorithms.

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## Methodology

### *Software reliability models*

Software reliability models show random process forms, as it periodically determines the behavior of software failures. Models of software reliability appeared when people tried to understand its features, such as why the software is faulty and so on. People have tried to quantify the reliability of software [7].

Since the early 1970s, there have been created more than 200 software reliability models. However the question about how to assess the reliability of software remains unresolved.

The software reliability models are sown in Table 1.

**Table 1:** Software reliability models (Neufelder, 2017)

| Model | Inputs Number | Industry supported | Effort required to use the model | Relative accuracy | Year developed/ Last updated |
|---|---|---|---|---|---|
| Industry tables | 1 | Several | Quick | Varies | 1992, 2015 |
| CMMI® tables | 1 | Any | Quick | Low at low CMMi® | 1997, 2012 |
| Shortcut model | 23 | Any | Moderate | Medium | 1993, 2012 |
| Full-scale model | 94-299 | Any | Detailed | Medium-High | 1993, 2012 |
| Metric based models | Varies | Any | Varies | Varies | NA |
| Historical data | A minimum of 2 | Any | Detailed | High | NA |
| Rayleigh model | 3 | Any | Moderate | Medium | NA |
| RADC TR-92-52 | 43-222 | Aircraft | Detailed | Obsolete | 1978, 1992 |
| Neufelder model | 156 | Any | Detailed | Medium to high | 2015 |

Reliability determines the end result of software. During fierce competition, any software should not only provide the necessary functionality, but also provide some additional benefits to end users. Developing software is a tedious and time-consuming process, like an experiment. Thus, ensuring the reliability of software should be the primary goal of the appropriate model specified, adopted, and selected by the organization listed above. One of the methods of ensuring the reliability of the software is the Vikor method.

## Literature review

Some tasks in which the VIKOR method is applied are reviewed below.

1. Compromise VIKOR method is used in linear programming task. Real decision-making problems often involve the consideration of many opposing goals. MCD is an experimental basis in relevant fields. [3] examines the problem of fuzzy MCD, in which all parameters are fuzzy, and offers a solution using the multi-criterion VIKOR method. The offered method seeks to find a fuzzy effective solution to the problem by minimizing the distance from ideal and anti-ideal solutions. Applying this method may disclose effective boundary for this issue. The applicability of the proposed method is shown in the example and the application is generalized to the investment problem. Both examples demonstrate the usefulness of this method.
2. Vahdani, Salimi and Mousavi (2015) suggests a method based on the VIKOR method as a compromise method to solve extensive nonlinear programming tasks. The proposed method was first introduced to solve extensive nonlinear programming in a fuzzy environment. This problem involves fuzzy ratios in both objective functions and constraints. In this method, the aggregate function based on the LP metric approaches the "ideal" solution based on a special "proximity" dimension. The solution process consists of two stages. The first uses the decomposition algorithm to reduce the q-dimensional space to a one-dimensional space. Then, to solve the problem, multi-purpose identical nonlinear programming is obtained from each fuzzy nonlinear model. The

second one solves the problem of large-scale single-purpose nonlinear programming to find the final solution. An illustrative example is provided to substantiate the proposed method.

3. Being introduced as a Multi-Attribute Decision Making (MADM) method, the VIKOR method resolves decision-making issues through separate and contradictory criteria. It seeks to list, select the number of alternatives on the basis of a certain "proximity" metric to an "ideal" solution. A multi-criteria method developed for compromise sorting is based on l-p metric applied in the compromise programming method as an aggregate function. This study extends the VIKOR method to resolve extended non-linear programming tasks with block-angle structure. This approach applies Dantzig-Wolfe fragmentation algorithm along with the Y-dimensional target area reduced to a one-dimensional area by expanding the concepts of the VIKOR method to make decisions in a sustainable environment. Finally, the paper presents an example to demonstrate and explain the foremost outcomes obtained in this study (Heydari, Sayadi & Shahanaghi, 2010).
4. The VIKOR and TOPSIS multi-criteria decision methods are based on a set of aggregate functions that represent the "ideal proximity" arising from compromise programming. The VIKOR uses linear normalization, while the TOPSIS uses vector normalization in order to exclude criteria function units. VIKOR's compromise ranking method determines the maximum "group benefit" for the "majority" and a compromise solution for the "competitor". The TOPSIS method defines the solution at the shortest distance to the ideal solution and the longest distance to the negative ideal solution, however it cannot take into account the relative importance of these distances. Opricovic (2011) explains a comparative analysis of these two methods in an example and demonstrates some differences and similarities.
5. Emission problems have obliged energy organisations to apply cleaner energy sources such as renewable and hydroelectric technologies. Nevertheless, the optimal use of reservoirs has been highlighted in recent decades due to water insufficiency in many areas. In this regard, Simab, Javadi and Nezhad (2018) offers a multi-purpose model for short-term hydrothermal planning issue when pumped storage technology is available. It uses VIKOR method to solve the task. The effectiveness of the proposed model is tested by comparing the results obtained with four sample studies using different methods.
6. The linguistic ambiguity of a particular fuzzy set derived from linguistic terms may represent the qualitative preferences of decision-makers, as well as their uncertainties and hesitations. In this study, a new VIKOR method is used to solve multi-criterion decision tasks. The paper analyzes an evaluation sample of a smart transport system to demonstrate the effectiveness and expediency of the proposed method (Dong, Yuan & Wan, 2017).
7. Digital control machines are used for high-precision, repetitive, complex and dangerous production operations. However, there are several decision-making criteria to be considered when choosing the right one. Fuzzy VIKOR-based multi-criteria group decision-making method offered to solve the problem in the work. Triangular fuzzy numbers denote the linguistic variables, which replicate decision-makers' preferences related to weights of criterion significance and evaluation of their effectiveness. This study develops two algorithms based on a fuzzy linguistic approach. It proposes a common method based on these two algorithms and the VIKOR method (Wu, Ahmad & Xu, 2016).
8. Alguliyev, Aliguliyev and Mahmudova (2015) uses a modified fuzzy VIKOR method for multi-criteria assessment of information culture of individuals. The VIKOR method is considered more proper for resolving the individual selection problem. A modified fuzzy VIKOR method developed in the paper ranks the alternatives. It presents comparative analysis of the outcomes of fuzzy and modified fuzzy VIKOR methods. Experience shows that the proposed modified fuzzy VIKOR method has a number of benefits over the conventional fuzzy VIKOR method. The presented model is efficient in terms of computational complexity.

## About the VIKOR method

Different methods are used to determine the reliability of software. One of them is the VIKOR method. Brief information about this method is given below. The VIKOR method is a multi-criteria decision (MCD) or multi-criteria decision analysis method. It categorizes alternatives, identifies the one closest to the so-called compromise ideal. A compromise solution was first proposed in 1973 by Po-Lung Yu and Milan Green.

It was stated that a compromise was acceptable, initially offered by Seraphim Opricovic for conflict resolution problem solving and diverse (different sections) criteria, that the decision-maker wanted the solution closest to the

ideal and evaluated all alternatives based on defined criteria. The method evaluates the alternatives, identifies a solution called compromise that is closest to the ideal (Opricovic & Gwo-Hshiung, 2007).

Sayadi offered main ideas about VIKOR in his thesis in 1979, and information on its application was published in 1980. The name VIKOR originated from the Serbian language in 1990: Multi-value and Optimization of Compromise solution (VIseKriterijumska Optimizacija I Kompromisno Resenje, Vikor). In 1998, real expressions were introduced. The VIKOR method was internationally recognized in the document adopted in 2004 (Sayadi., Heydari & Shahanaghi, 2009). As a result, a compromise solution can be provided by those who make decisions, as it provides the maximum utility of the majority and the minimum failure of the individual competitor. Measures are integrated for a compromise solution, which is the basis of an agreement recognised by mutual concessions.

## Conclusion

The fuzzy VIKOR method is designed for the solution of task in fuzzy environment. Here, both criteria and weights may be fuzzy. To control uncertain numerical quantities, triangular fuzzy numbers are applied. Fuzzy VIKOR is based on fuzzy work that characterizes and combines the length of an ideal solution alternative. Fuzzy operations and fuzzy ranking procedures play a key role in the development of fuzzy VIKOR algorithm. Applying this method, the reliability of software can be achieved.

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