Studies in Fuzziness and Soft Computing

Volume 398

Series Editor

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Fine–Kinney-Based Fuzzy Multi-criteria Occupational Risk Assessment

Approaches, Case Studies and Python Applications

Springer

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ISSN 1434-9922 ISSN 1860-0808 (electronic)
Studies in Fuzziness and Soft Computing
ISBN 978-3-030-52147-9 ISBN 978-3-030-52148-6 (eBook)
https://doi.org/10.1007/978-3-030-52148-6

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

*To my dad **Ali**, mom **Fevziye**, wife **Tuğba** and children, **Ahmet Faruk** and **Zeynep Sena***

Muhammet Gul

*To my dad **Mahmut**, mom **Latife**, wife **Hayriye** and children, **Yusuf** and Latife Nisa*

Suleyman Mete

*To **Sabri, Abdulkadir, Zülfiye, Hediye, Emine, Muhammed Rohat, Alya Nil***

Faruk Serin

*To my dad **Cemil**, mom **Zeliha**, wife **Canan**, and son **Muhammed***

Erkan Celik

Preface

Since its development as an occupational risk assessment method in the 1970s [1, 2], Fine–Kinney method has been extensively applied to a diversity number of safety risk assessment problems of various industries. It is considered as a systematic methodology presenting a formula for calculating the risk due to a hazard. Classically, safety risk assessment via Fine–Kinney is carried out by a score which is the arithmetic product of probability (P), exposure (E) and consequence (C). Calculated risk scores help decision-makers prioritize corrective and preventive actions. This simple, easily understood and useful method is practically used by small and medium enterprises for their risk analysis processes. On the other side, in the academic knowledge, Fine–Kinney method is yet applied to various areas recently although it has several drawbacks. Since this method aims to prioritize the hazards and associated risks depending on three different parameters, the problem that this method tries to solve can be considered as a classic multi-criteria decision-making (MCDM) problem.

MCDM methods are frequently applied to occupational risk assessment problems by many scholars. In MCDM methods with crisp and precise data, the performance ratings and the weights of the decision criteria are known precisely and indicated by crisp numbers. However, many real-world problems involve uncertain data and one cannot assume the knowledge and judgments of the experts to be precise. Hence, fuzzy-based MCDM methods are proposed to reflect types and degrees of uncertainties better than classical ones. At this point, this book offers a number of approaches to Fine–Kinney-based multi-criteria occupational risk assessment.

Occupational risk assessment is a sub-process of risk management for evaluating of the risks arising from a hazard, considering the required control measures and deciding whether the risks are acceptable or not. It includes the determination of a quantitative or qualitative value for the risk. Several approaches to perform occupational risk assessment are available in the literature ranging from expert to participatory methodologies and from simple to complex methods. The Fine–Kinney method is an exhaustive occupational risk assessment method for quantitative evaluation of the hazards.

The book provides valuable insights into useful Fine–Kinney-based fuzzy multi-criteria occupational risk assessment approaches, case studies that can show the applicability of each proposed approach and Python coding of each proposed approach that can be useful for stakeholders to easy implement those to their risk assessment process.

The book is organized to include nine chapters. Chapter 1 contains the basics of Fine–Kinney method with its implementing procedure, its basic terminology and drawbacks. In addition to this necessary information, a state-of-the-art review is provided including its extensions by fuzzy sets. Graphical results obtained from the review are demonstrated to show the current state-of-the-art. Future work suggestions are also included in the chapter to show the possible gaps and possible opportunities.

Chapter 2 introduces a Fine–Kinney-based occupational risk assessment using fuzzy best and worst method (F-BWM) and fuzzy multi-attribute ideal real comparative analysis (F-MAIRCA). In this chapter, instead of crisp numbers, triangular fuzzy numbers that reflect the uncertainty well in real-world problems are used in integration with BWM method in determining Fine–Kinney risk parameters. The risks are then prioritized by F-MAIRCA. A case study for the occupational risk assessment of raw mill processes in a cement factory has been conducted to demonstrate the feasibility of the approach, and besides this case study, a comparative study has also been conducted to test the validity of the proposed approach. Python implementation has been done to help stakeholders easy model its safety problem by adapting this novel approach.

Chapter 3, an improved Fine–Kinney occupational risk assessment approach is proposed using a well-known MCDM method "TOPSIS" under interval type-2 fuzzy set concept. It is defined as technique for order preference by similarity to ideal solution by Hwang and Yoon (1980). It is based on separation from ideal and anti-ideal solution concept. Interval type-2 fuzzy set is an improved version of type-1 fuzzy set. It is also special version of a general type-2 fuzzy set. Since general type-2 fuzzy systems contain complex computational operations, they have not easily applied to real-world problems such as occupational risk assessment. Interval type-2 fuzzy sets are the most frequently used type-2 fuzzy sets due to their ability in handling more uncertainty and producing more accurate and solid results. The Fine–Kinney concept is merged with interval type-2 fuzzy set concept and TOPSIS for the first time through the literature. To demonstrate the applicability of the proposed approach, a case study is carried out in a chrome plating unit of a gun factory. Some beneficial validation and sensitivity analysis are also performed. Finally, as a creative contribution of our book, the implementation of the proposed approach in Python is performed.

Chapter 4 aims at adaptation of Fine–Kinney occupational risk assessment concept into VIKOR multi-attribute decision making method with interval-valued Pythagorean fuzzy set. The classical fuzzy set theory has been improved by proposing a number of extended versions. One of them is Pythagorean fuzzy set. In this chapter, we use this type of fuzzy set with VIKOR since it reflects uncertainty in occupational risk assessment and decision-making better than other fuzzy

extensions. To demonstrate the proposed approach applicability, a case study regarding the activities of surface treatment area in a chrome plating unit of a gun factory is performed. Some additional analysis to test the solidity and validity of the approach is executed. Finally, the Python codes in the implementation of the proposed approach are given for scholars and practitioners for usage in further studies.

Chapter 5 applies a novel occupational risk assessment approach which merges the TODIM with Fine–Kinney method under intuitionistic fuzzy set concept. Risk parameters of Fine–Kinney and OHS experts are weighted by an intuitionistic fuzzy weighted averaging (IFWA) aggregation operator. Hence, hazards are quantitatively evaluated and prioritized using the proposed approach. To illustrate the novel risk assessment approach, processes of the gun and rifle assembly line of a factory are handled. A comprehensive risk assessment is carried out to improve operational safety and reliability in the industry. We adapt intuitionistic fuzzy sets in the existed study since they reflect uncertainty with a aid of their membership and non-membership functions in decision-making better than classical fuzzy extensions. An additional sensitivity analysis by changing the attenuation parameter of TODIM is performed to test the validity of the approach. Finally, the Python codes in the implementation of the proposed approach are given provided as well.

Chapter 6, a Fine–Kinney-based occupational risk assessment using hexagonal fuzzy multi-objective optimization by ratio analysis (HFMULTIMOORA) is handled. Hexagonal fuzzy numbers (HFNs) can be used as a proficient logic to simplify understanding of ambiguity information. HFNs present the usual information in a comprehensive way and also the ambiguity section can be exemplified in a reasonable way. In this chapter, we proposed an improved Fine–Kinney occupational risk assessment approach using an integration of MULTIMOORA and HFNs. To show the applicability of the novel approach, a case study of risk assessment of a raw mill in cement plant was provided. Comparative analysis using two aggregation tools as reciprocal rank method and dominance theory is carried out. Finally, the Python implementation of the proposed approach is implemented to be effective for those concerned in the future.

Chapter 7 includes an improved Fine–Kinney approach using neutrosophic sets. Neutrosophic sets reflect uncertainty and vagueness in real-world problems better than classical fuzzy set theory. It takes into three decision-making situations consideration called indeterminacy, truthiness, and falsity. In Zadeh's traditional fuzzy set theory, there is just membership function fuzzy set degree. But, in neutrosophic environment, it considers three membership functions. Unlike intuitionistic fuzzy sets, an indeterminacy degree is considered. In this chapter, we applied a special form of neutrosophic set as single-valued neutrosophic set (SVNs) with TOPSIS under the concept of Fine–Kinney occupational risk assessment. Since the mere TOPSIS has failed to handle imprecise and vague information which usually exist in real-world problems, we follow integration of SVNs and TOPSIS. To demonstrate the applicability of the novel approach, a case study of risk assessment of a wind turbine in times of operation was provided. Comparative analysis with some similar approaches and sensitivity analysis by changing the weights of Fine–Kinney

parameters are carried out. Finally, the Python implementation of the proposed approach is executed as in other chapters.

Chapter 8, we improved Fine–Kinney occupational risk assessment approach with interval type-2 fuzzy QUALIFLEX (IT2FQAULIFLEX). QAULIFLEX is an outranking multi-attribute decision-making method proposed by an extension of Paelinck's generalized Jacquet-Lagreze's permutation method. Similar to other outranking solution-based approaches, it considers the solution which is comparison of hazards. In this chapter, we adapted the interval type-2 fuzzy sets (IT2FSs) into QAULIFLEX as it reflects the uncertainty well in decision-making. IT2FQAULIFLEX algorithm under the Fine–Kinney concept provides a useful and solid approach to the occupational health and safety risk assessment. In addition to proposing this new approach, a case study is performed in chrome plating unit. A validation is also performed in this study. Finally, the proposed approach is implemented in Python.

Final chapter (Chap. 9) provides an improved Fine–Kinney occupational risk assessment approach with interval type-2 fuzzy VIKOR (IT2FVIKOR). VIKOR is a compromise multi-attribute decision-making method proposed by Opricovic (1998). Similar to other compromised solution-based approaches, it considers the solution which is closest to the ideal. In this chapter, we adapted the interval type-2 fuzzy sets (IT2FSs) into VIKOR as it reflects the uncertainty well in decision-making. IT2FVIKOR algorithm under the Fine–Kinney concept provides a useful and solid approach to the occupational health and safety risk assessment. In addition to proposing this new approach, a case study is performed in a gun and rifle barrel external surface oxidation and colouring unit of a gun factory. A validation and a sensitivity analysis are also attached to this study. Finally, the proposed approach is implemented in Python.

This book will be one of the most important guidance books of professionals and researchers working in the field of occupational risk management. It can be considered as a guide document for how an industrial organization proactively identifies, manages and mitigates the risk of patient hazard. It also aims to become a valuable reference book for postgraduate and undergraduate students.

Finally, we, as the four editors of this book, are grateful to our families for their constant love, patience and support. Without their unique support, we would not have been able to complete this book. With the best wishes that the book will be useful to all concerned.

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March 2020

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Contents