

Qiumei Wang and Jianming Zhan\*

# Rough semigroups and rough fuzzy semigroups based on fuzzy ideals

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**Abstract:** In this paper, we firstly introduce a special congruence relation  $U(\mu, t)$  induced by a fuzzy ideal  $\mu$  in a semigroup  $S$ . Then we define the lower and upper approximations based on a fuzzy ideal in semigroups. We can establish rough semigroups, rough ideals, rough prime ideals, rough fuzzy semigroups, rough fuzzy ideals and rough fuzzy prime ideals according to the definitions of rough sets and rough fuzzy sets. Furthermore, we shall consider the relationships among semigroups and rough semigroups, fuzzy semigroups and rough fuzzy semigroups, and some relative properties are also discussed.

**Keywords:** Fuzzy ideal,  $t$ -level set, Rough semigroup, Rough fuzzy semigroup, Rough (prime) ideal, Rough fuzzy (prime) ideal

**MSC:** 20N20, 16Y99

## 1 Introduction

In 1965, the notion of fuzzy sets was introduced by Zadeh [1] and he gave the way to study uncertainty problems. Thereafter, the theory has developed quickly and has been applied in many areas of our real world. Up to now, fuzzy mathematics has remained an important branch of mathematics. Meanwhile, in the early 20th century, some researchers began to research semigroups formally. Since 1950, the investigations of finite semigroups have become rather important in theoretical computer science because there are natural relations between finite semigroups and finite automations. With the fuzzy mathematics being deeply studied, fuzzy algebras were also investigated. The study of fuzzy algebras is also one of the most important directions in fuzzy mathematics. In particular, a great number of studies on fuzzy groups and fuzzy semigroups were performed. It should be pointed out that the studies on fuzzy semigroups are deeply influencing the development of fuzzy theory. In recent years, a large number of fuzzy algebras have been developed by some scholars, for instances see [2–4]. Especially, Davvaz [5], Dudek [6] and Zhan [7] applied fuzzy theory to  $n$ -ary semigroups. Recently, Zhan [8, 9] studied some types of fuzzy  $k$ -ideals and fuzzy  $k$ -ideals of hemirings, respectively.

In 1982, Pawlak [10] firstly developed a rough set theory. It is rather important to deal with inexact, uncertain, or vague situations. More and more researchers have been attracted to study rough sets and their applications. While mentioning rough sets, we can not neglect the lower and upper approximations. In Pawlak rough sets, the equivalent relations are essential to construct the lower and upper approximations. To deal with imperfect data, rough set theory is a powerful theory [11]. In recent years, Bonikowski [12], Iwinski [13], and Pomykala [14] have studied algebraic properties of rough sets. The notion of rough subgroups was introduced by Biswas and Nanda [15]. Then, Kuroki [16] put up the notion of rough ideals in semigroups. Also, in [17], Jun investigated the roughness of  $\Gamma$ -subsemigroups

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# Fuzzy Semigroups Fuzzy Semigroups

**John N. Mordeson, Davender S.  
Malik, Nobuaki Kuroki**



## **Fuzzy Semigroups Fuzzy Semigroups:**

**Fuzzy Semigroups** John N. Mordeson, Davender S. Malik, Nobuaki Kuroki, 2012-11-03 Lotfi Zadeh introduced the notion of a fuzzy subset of a set in 1965. His seminal paper has opened up new insights and applications in a wide range of scientific fields. Azriel Rosenfeld used the notion of a fuzzy subset to put forth cornerstone papers in several areas of mathematics among other disciplines. Rosenfeld is the father of fuzzy abstract algebra. Kuroki is responsible for much of fuzzy ideal theory of semigroups. Others who worked on fuzzy semigroup theory such as Xie are mentioned in the bibliography. The purpose of this book is to present an up to date account of fuzzy subsemigroups and fuzzy ideals of a semigroup. We concentrate mainly on theoretical aspects but we do include applications. The applications are in the areas of fuzzy coding theory, finite state machines and fuzzy languages. An extensive account of fuzzy automata and fuzzy languages is given in 100. Consequently we only consider results in these areas that have not appeared in 100 and that pertain to semigroups. In Chapter 1 we review some basic results on fuzzy subsets, semigroups, codes, finite state machines and languages. The purpose of this chapter is to present basic results that are needed in the remainder of the book. In Chapter 2 we introduce certain fuzzy ideals of a semigroup, namely fuzzy two sided ideals, fuzzy bi ideals, fuzzy interior ideals, fuzzy quasi ideals and fuzzy generalized bi ideals.

**Fuzzy Semigroups** Susan Beers Browder, 1990 *Semigroups, Algebras and Operator Theory* P. G. Romeo, John. C. Meakin, A. R. Rajan, 2015-07-06 This book discusses recent developments in semigroup theory and its applications in areas such as operator algebras, operator approximations and category theory. All contributing authors are eminent researchers in their respective fields from across the world. Their papers presented at the 2014 International Conference on Semigroups, Algebras and Operator Theory in Cochin, India, focus on recent developments in semigroup theory and operator algebras. They highlight current research activities on the structure theory of semigroups as well as the role of semigroup theoretic approaches to other areas such as rings and algebras. The deliberations and discussions at the conference point to future research directions in these areas. This book presents 16 unpublished high quality and peer reviewed research papers on areas such as structure theory of semigroups, decidability vs undecidability of word problems, regular von Neumann algebras, operator theory and operator approximations. Interested researchers will find several avenues for exploring the connections between semigroup theory and the theory of operator algebras.

**Smarandache Fuzzy Algebra** W. B. Vasantha Kandasamy, 2003 The author studies the Smarandache Fuzzy Algebra which like its predecessor Fuzzy Algebra arose from the need to define structures that were more compatible with the real world where the grey areas mattered not only black or white. In any human field a Smarandache  $n$  structure on a set  $S$  means a weak structure  $w_0$  on  $S$  such that there exists a chain of proper subsets  $P_{n-1} \subset P_{n-2} \subset \dots \subset P_2 \subset P_1 \subset S$  whose corresponding structures verify the chain  $w_{n-1} \text{ includes } w_{n-2} \text{ includes } \dots \text{ includes } w_2 \text{ includes } w_1 \text{ includes } w_0$  where includes signifies strictly stronger. i.e. structure satisfying more axioms. This book is referring to a Smarandache 2 algebraic structure, two levels only of structures.

in algebra on a set  $S$  is a weak structure  $w_0$  on  $S$  such that there exists a proper subset  $P$  of  $S$  which is embedded with a stronger structure  $w_1$

Properties of Smarandache fuzzy semigroups groupoids loops bigroupoids biloops non associative rings birings vector spaces semirings semivector spaces non associative semirings bisemirings near rings non associative near ring and binear rings are presented in the second part of this book together with examples solved and unsolved problems and theorems Also applications of Smarandache groupoids near rings and semirings in automaton theory in error correcting codes and in the construction of  $S$  subbiautomaton can be found in the last chapter

**Proceedings of the 2012 International Conference on Cybernetics and Informatics** Shaobo Zhong, 2013-08-23 Proceedings of the International Conference on Cybernetics and Informatics ICCI 2012 covers the hybridization in control computer information communications and applications ICCI 2012 held on September 21-23 2012 in Chongqing China is organized by Chongqing Normal University Chongqing University Nanyang Technological University Shanghai Jiao Tong University Hunan Institute of Engineering Beijing University and sponsored by National Natural Science Foundation of China NSFC This two volume publication includes selected papers from the ICCI 2012 Covering the latest research advances in the area of computer informatics cybernetics and applications which mainly includes the computer information control communications technologies and applications

**Interval Semigroups** W. B. Vasantha Kandasamy, Florentin Smarandache, 2011 In this book for the first time the concept of interval semigroups using intervals of the form  $[0, a]$  is defined Several types of interval semigroups are introduced and their properties are analyzed A special feature of this book is the wide range of examples and problems

Neutrosophic and Plithogenic Inventory Models for Applied Mathematics Smarandache, Florentin, Jdid, Maissam, Leyva-Vazquez, Maikel, 2025-05-29 As professionals navigate the evolving landscapes shaped by the advent of artificial intelligence a critical void emerges in the optimization paradigms of applied mathematics The dynamism of our interconnected world demands a collective research effort that transcends traditional boundaries In response to this pressing need Neutrosophic and Plithogenic Inventory Models for Applied Mathematics proposes a groundbreaking exploration within the frameworks of neutrosophic and plithogenic theories This work not only seeks to address the profound impact of artificial intelligence on our lives but also aims to redefine the very foundations of optimization Embark on a profound journey through the unexplored territories of neutrosophic and plithogenic concepts Discover the transformative potential of neutrosophic set logic probability and statistics as well as plithogenic set logic probability and statistics Explore the synergy between artificial intelligence and responsive optimization and navigate the intricacies of plithogenic cognitive maps This work further explores the structural designs within neutrosophic optimization offering an invaluable resource for scholars seeking to incorporate these advanced concepts into static dynamic and probabilistic inventory models and their myriad applications

**Fuzzy and Neutrosophic Sets in Semigroups** Young Bae Jun, Madad Khan, Florentin Smarandache, Saima Anis, 2018-01-01 The topics discussed in this book are Int soft semigroup Int soft left right ideal Int soft generalized bi ideal Int soft quasi ideal Int soft

interior ideal Int soft left right duo semigroup starshaped qk fuzzy set quasi starshaped qk fuzzy set semidetached mapping semidetached semigroup qk fuzzy subsemi group qk qk fuzzy subsemigroup qk fuzzy subsemigroup qk qk fuzzy subsemigroup qk qk fuzzy subsemigroup qk fuzzy subsemigroup qk level subsemigroup bi ideal qk fuzzy generalized bi ideal lower upper approximation of fuzzy set lower upper rough fuzzy subsemigroup rough fuzzy subsemigroup Neutrosophic N structure neutrosophic N subsemigroup neutrosophic N subsemigroup and neutrosophic N product

**Neutrosophic Set Approach to Algebraic Structures** Madad Khan, Florentin Smarandache, Saima Anis, Fazal Tahir, This book consists of seven chapters In chapter one we introduced neutrosophic ideals bi quasi interior m n ideals and discussed the properties of these ideals Moreover we characterized regular and intra regular AG groupoids using these ideals In chapter two we introduced neutrosophic minimal ideals in AG groupoids and discussed several properties In chapter three we introduced different neutrosophic regularities of AG groupoids Further we discussed several condition where these classes are equivalent In chapter four we introduced neutrosophic M systems and neutrosophic p systems in non associative algebraic structure and discussed their relations with neutrosophic ideals In chapter five we introduced neutrosophic strongly regular AG groupoids and characterized this structure using neutrosophic ideals In chapter six we introduced the concept of neutrosophic ideal neutrosophic prime ideal neutrosophic bi ideal and neutrosophic quasi ideal of a neutrosophic semigroup With counter example we have shown that the union and product of two neutrosophic quasi ideals of a neutrosophic semigroup need not be a neutrosophic quasi ideal of neutrosophic semigroup We have also shown that every neutrosophic bi ideal of a neutrosophic semigroup need not be a neutrosophic quasi ideal of a neutrosophic semigroup We have also characterized the regularity and intra regularity of a neutrosophic semigroup In chapter seven we introduced neutrosophic left almost rings and discussed several properties using their neutrosophic ideals

**Keywords** neutrosophic set algebraic structure neutrosophic ideal AG groupoids neutrosophic minimal ideals neutrosophic regularities neutrosophic M systems neutrosophic p systems neutrosophic strongly regular AG groupoids neutrosophic prime ideal neutrosophic bi ideal neutrosophic quasi ideal neutrosophic semigroup neutrosophic left almost rings

**Some characterizations of S-a fuzzy semigroups by their a level subgroups** Gowri R., Rajeswari T.,

Recent Advances in Modeling, Analysis and Systems Control: Theoretical Aspects and Applications El Hassan Zerrik, Said Melliani, Oscar Castillo, 2019-08-26 This book describes recent developments in a wide range of areas including the modeling analysis and control of dynamical systems and explores related applications The book provided a forum where researchers have shared their ideas results on theory and experiments in application problems The current literature devoted to dynamical systems is quite large and the authors choice for the considered topics was motivated by the following considerations Firstly the mathematical jargon for systems theory remains quite complex and the authors feel strongly that they have to maintain connections between the people of this research field Secondly dynamical systems cover a wider range of applications including engineering life sciences and environment The

authors consider that the book is an important contribution to the state of the art in the fuzzy and dynamical systems areas  
Algebraic Structures Using Super Inter Interval Matrices W. B. Vasantha Kandasamy, Florentin Smarandache, 2011

**Neutrosophic Set Approach for Characterizations of Left Almost Semigroups** Madad Khan, Florentin Smarandache, Sania Afzal, In this paper we have defined neutrosophic ideals neutrosophic interior ideals neutrosophic quasi ideals and neutrosophic bi ideals neutrosophic generalized bi ideals and proved some results related to them Learning Technologies and Systems Chaoyi Pang, Yunjun Gao, Guanliang Chen, Elvira Popescu, Lu Chen, Tianyong Hao, Bailing Zhang, Silvia Margarita Baldiris Navarro, Qing Li, 2021-01-22 This book constitutes the refereed conference proceedings of the 19th International Conference on Web Based Learning ICWL 2020 and 5th International Symposium on Emerging Technologies for Education SETE 2020 held in Ningbo China in October 2020 Together for the ICWL 2020 Conference and SETE 2020 Symposium 39 full papers were accepted together with 31 short papers out of 233 submissions The papers focus on the following subjects Semantic Web for E Learning through Learning Analytics Computer Supported Collaborative Learning Assessment Pedagogical Issues E learning Platforms and Tools to Mobile Learning and much more

**Applications of Neutrosophic N-Structures In Ternary Semigroups** Amornrat Rattana, Ronnason Chinram, In this paper the notions of neutrosophic N ternary subsemigroups of ternary semigroups are introduced and several properties are investigated **A Guide to the Literature on Semirings and their Applications in Mathematics and Information Sciences** K. Glazek, 2013-06-29 This volume presents a short guide to the extensive literature concerning semirings along with a complete bibliography The literature has been created over many years in variety of languages by authors representing different schools of mathematics and working in various related fields In many instances the terminology used is not universal which further compounds the difficulty of locating pertinent sources even in this age of the Internet and electronic dissemination of research results So far there has been no single reference that could guide the interested scholar or student to the relevant publications This book is an attempt to fill this gap My interest in the theory of semirings began in the early sixties when together with Bogdan W. Glazek I tried to investigate some algebraic aspects of compactifications of topological spaces semirings of semicontinuous functions and the general ideal theory for special semirings Unfortunately local algebraists in Poland told me at that time that there was nothing interesting in investigating semiring theory because ring theory was still being developed However some time later we became aware of some similar investigations having already been done The theory of semirings has remained my first love ever since and I have been interested in the results in this field that have been appearing in literature even though I have not been active in this area myself *Finite Neutrosophic Complex Numbers* W. B. Vasantha Kandasamy, Florentin Smarandache, 2011 The Journal of Fuzzy Mathematics, 2007 *Theory of Abel Grassmann's Groupoids* Madad Khan, Florentin Smarandache, Saima Anis, 2015-04-01 We extend now for the first time the AG groupoid to the Neutrosophic AG groupoid A neutrosophic AG groupoid is a

neutrosophic algebraic structure that lies between a neutrosophic groupoid and a neutrosophic commutative semigroup

**Algebraic Structures on MOD Planes** W. B. Vasantha Kandasamy, K. Ilanthenral, Florentin Smarandache, 2015-11-01

Study of MOD planes happens to a very recent one In this book systematically algebraic structures on MOD planes like MOD semigroups MOD groups and MOD rings of different types are defined and studied Such study is innovative for a large four quadrant planes are made into a small MOD planes Several distinct features enjoyed by these MOD planes are defined developed and described

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