ABSTRACT

In this paper we propose a fuzzy rule generation approach based on granular computing using rough mereology (FRGAGCRM). The proposed system works in two phases. In the first phase, the pre-processing phase which use fuzzification methodology which map the numeric dataset into categorical dataset according to membership function described in this paper. In other hand, the second phase consists of the rough mereology phase and rule generation phase. The rules are generated by rough mereology and rough inclusion techniques. The experimental results using Irvine, ML Repository dataset show that FRGAGCRM is better than RGAGCRM, ID3, and RGAGC. The performance measure of FRGAGCRM is compared with the performance of RGAGCRM, ID3, and RGAGC in same dataset. The result obtained empirically demonstrates that the proposed FRGAGCRM performs superior.

KEY WORDS
Rough Mereology, Rough Inclusion, Rule Generation, Granular Computing, Fuzzy logic.

1. INTRODUCTION

The concept of reality granulation comprised first acquainted by Zadeh [1] in the context of fuzzy sets in 1979. The primary themes of crisp information granulation hold seemed in related disciplines, such interval analysis, quantization, rough set theory, Dempster-Shafer theory of belief functions, divide and conquer, cluster analysis, machine learning, databases, and many others. However, fuzzy information granulation has not obtained adequate aid [2]. In a series of recent papers and invited talks, Zadeh, proposed the development of a theory of fuzzy information granulation. Motivated by the work of Zadeh, there is a fast growing interest in the study of information granulation and computations under the umbrella of Granular Computing (GrC). There are theoretical and practical concludes for the study of granular computing which simulate human brain to solve human problems by computer machine. A lot of authors indicated that information granulation is very requisite.
to human problem solving, and therefore has a very important effect on the
design and implement of intelligent systems. Zadeh [2] identified three basic
concepts that underlie human cognition, namely, granulation, organization, and
causation. “Granulation involves decomposition of whole into parts,
organization involves integration of parts into whole, and causation involves
computing using neighborhood systems for the interpretation of granules.
Pawlak [5], Skowron and Stepaniuk [6], Polkowski and Skowron [7] examined
granular computing in connection with the theory of rough sets, and Mahmood
et al. [8] examine rough mereology and t-norm rough inclusion for granular
computing using information table to generate granules (rules). An Outstanding
characteristic of these studies is that a particular semantics interpretation of
granules is defined, and an algorithm for constructing granules is given. The
primary objective of the present study is to produce a simple and more practical
model for fuzzy granular computing using information tables. In summary,
granular computing is animated by the ways in which humans granulate
information and reason with information.
The rest of this paper is organized as follows. Section 2 presents introduction on
fuzzy system and describe the fuzzy membership function that used in paper. In
section 3, different phases of the proposed rule generation approach to granular
computing using rough mereology are presented. Section 4 introduces
experimental results. Finally, section 5 addresses conclusions and discusses
future work.

2. Fuzzy membership function
Fuzzy system was first proposed by an American professor, Zadeh, in 1965
when he presented his seminal paper on “fuzzy sets.”[10] Zadeh showed that
fuzzy logic unlike classical logic can realize value between false (0) and true (1).
Basically, he transformed the crisp set into the continuous set. Fuzzy logic is the
part of artificial intelligence or machine learning which interprets a human’s
action. Fuzzy logic has mostly been applied to control systems. Fuzzy control
systems interpret the expert human and replace them for performing certain
tasks such as control of a power plant. Fuzzification is the process of changing a
real scalar value into a fuzzy value. This is achieved with the different types of
fuzzifiers. There are generally three types of fuzzifiers, which are used for the
fuzzification process; they are 1) singleton fuzzifier, 2) Gaussian fuzzifier, and
3) trapezoidal or triangular fuzzifier. The proposed membership function use the
triangular and trapezoidal fuzzifiers are shown in fig.1.

![Fig. 1 fuzzy membership function](image-url)
Where  
\[
d = \frac{(\text{max} - \text{min})}{6}
\]
And

3. Fuzzy Rule Generation Approach to Granular Computing using Rough Mereology

In this section, we explain the proposed rule generation approach to granular computing using rough mereology. The proposed approaches contains five phases: Information System Table phase, classify data set check, if data set is numerical, then go-to Fuzzification phase, otherwise Rough Mereology phase, Rough Inclusion Matrix phase, and Generate set of rules phase. These five phases are described in detail in the following section along with the steps involved and the characteristics feature for each stage.

A) Information system table phase. A classical information table is depicted in Table 1 [8]; if dataset includes numerical data then go to section B otherwise go to section C.

B) Fuzzification phase. In this phase, applying the proposed membership function on dataset to get a classical dataset then go to section C.

C) Rough mereology phase. The set of inclusion is returned from step2 of Algorithm (I) by getting the linguistic value if dataset of information table is classical or categories data, then we depict from each one objects in table satisfy which linguistic attributes.

D) Rough inclusion matrix phase and Generate set of rules phase. These phases same as the corresponding phase in [8].

3.1. Algorithm

E) The proposed approach gets the inputs dataset as classical or continuous, then initializes an empty rough inclusion set, and builds classical information set from numerical dataset according to fuzzification methodology. The rough inclusion set builds According to equation described in [9], so it generates the set of rules by rough inclusion t-norm technique in each tuple of rough inclusion set, finally, remove the duplicates of rules and compute the average accuracy rate. Algorithm (I) shows the detailed steps.

4. Simulation, Experimental Results, and Analysis

Initially, apiece data set is accustomed generate rules with these two algorithms separately. Then, apiece data set is want to test the recognition rate of rules by these three algorithms. Simulation experiment results are exhibited in Table2: Where Table2 represents the average rule length and the accuracy rate for each algorithm. From Fig.2 and Fig.3, we can find that the performance of proposed
approach and accuracy rate is more well-grounded than RGAGC and ID3 in some aspects, i.e., the average rule length of rules. The accuracy rate we used in this paper is defined in [8]. Our simulation experiments are done on a PC with 1.6GHZ CPU, 512MB memory. The proposed approaches and others are designed with program language java on the operation system Windows XP. The simulation experiments have been conducted on same data sets in [7, 8].

5. Conclusions and Future Work

Granular computing is a methodology simulates human brain to solve computer problems by divide main problem in sub-problems and make relation between these sub-problems with each other, from the above definition granular computing as same as classifiers which divide problem into clusters. Our approach used to divide dataset or information into groups according to some conditions like other classifier but differ in using the concept of granular computing which deal with rough dataset and reduce problem of rough set by using rough mereology technique so this approach may be useful in some fields such as recommender systems which can decrease complexity time.

REFERENCES


Fig. 2 Block diagram overall system
### Tab. 1 Dataset

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Record number</th>
<th>Attribute number</th>
<th>Attribute type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abalone Data</td>
<td>4177</td>
<td>8</td>
<td>Categorical &amp; Numerical</td>
</tr>
<tr>
<td>Car evaluation</td>
<td>1782</td>
<td>6</td>
<td>Categorical</td>
</tr>
<tr>
<td>Nursery database</td>
<td>12960</td>
<td>8</td>
<td>Categorical</td>
</tr>
<tr>
<td>Pima Indian diabetes</td>
<td>768</td>
<td>8</td>
<td>Numerical</td>
</tr>
<tr>
<td>Wisconsin prognostic breast</td>
<td>569</td>
<td>31</td>
<td>Numerical</td>
</tr>
</tbody>
</table>

### Tab. 2 Average rule length and percentage accuracy rate

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Average rule length</th>
<th>Percentage accuracy measure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RGAGCRM</td>
<td>FRGAGCRM</td>
</tr>
<tr>
<td>Abalone data</td>
<td>1.44</td>
<td>1.75</td>
</tr>
<tr>
<td>Car Evaluation</td>
<td>2.14</td>
<td>2.5</td>
</tr>
<tr>
<td>Nursery</td>
<td>2.67</td>
<td>2.75</td>
</tr>
<tr>
<td>Pima Indian diabetes</td>
<td>1.33</td>
<td>0.75</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>8.18</td>
<td>0.84</td>
</tr>
</tbody>
</table>

### Algorithm 1 RGAGCRM Algorithm

**Input:** An information System table (IST)  
**Output:** Rule granule set (RGS)  
**Classification IST**  
If IST is Numerical then apply fuzzification methodology on table and goto next step else goto next step  
Initialize Rough Inclusion set RIS =  
For each column in (IST) do  
Compute rough inclusion and put the values in RIS  
End for  
Initialize Rule generation set RGS =  
For each row in RIS do  
Get the rule according to definition of rough inclusion [9], and put the rule in RGS  
Remove duplicates rules from RGD  
Output rule generation set RGS  
End for  
Exit