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Team Achievements Equality Using Fuzzy Rule-based Technique

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Abstract: Team formation is important in industrial and academic institutions because the success of teams depend on assembling the right combination of team members. Prior academic achievement is one of the factors that affect teams' performances. Therefore, it is important to identify an effective technique that can determine equality amongst teams based on prior academic achievements. Having team with similar prior academic achievements can increase equality, reliability and validity in team formation before embarking on any research studies. This can be achieved by applying fuzzy rule-based technique. Fuzzy rule-based technique is suitable for this study because this technique allow analyzing of imprecise data and classifying selected criteria. Initial evaluation of this technique showed that it can indicate whether every team has equal distribution of prior academic achievements. By incorporating this technique in a team formation model, each team can be guaranteed to have equal chances to perform effectively. This technique can facilitate decision makers when forming highly productive project teams.

Key words: Team equality · Team achievements · Team formation · Fuzzy rule-based

INTRODUCTION

In this era of globalisation and competitiveness, teamwork becomes a central part of every workplace. Working as team is vital in ensuring successful organisational goals and strategies are met. In many workplaces, employee works as a team in industries such as engineering, manufacturing and construction. Many jobs cannot rely on one-man-show tasks because individuals have limited knowledge and capability. Therefore, working in teams expedites the completion of works by cultivating more ideas [1] and creating synergy amongst members in teams [2] thereby increasing teams productivity.

The success of teams depends on the grouping of the right members in a team [3-4]. However, to form a team that has members with similar academic achievements [5], experiences [6], or even personality types [3] is a challenging task. According to Ounnas *et al*. [7], most existing group formations used self-selecting approach whereby the students choose their own team members or instructor-selecting approach, where the instructors initiate the group formation. Nonetheless, these approaches often lead to a team that consists of unequal prior academic achievements amongst team members. This inequality leads to teams not having equal chances to compete with each others.

Biasness may exist if issue in inequality of academic achievements amongst team members is not resolved. This is because members faced difficulty to perform effectively as a team. This may limit members' ability in engaging and learning during teamwork activities. Therefore, this study aims to determine a technique that can ascertain equality of team members based on student's prior academic achievements. To develop a model, a fuzzy approach using rule-based technique was selected because it is allow imprecise data to be analysed and selected criteria to be classified.

Related Works

The Importance of Teamwork: Teams that have common characteristics are able to exchange ideas actively and thus able to create more interest amongst team members. According to [8], cooperative teams achieve higher levels of thought and retain information longer than those who work quietly as individuals. Vygotsky [9] argued that people are capable of performing at higher intellectual levels when working in collaborative situations than when

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working individually. The shared learning environments allow people opportunity to engage in depth discussions and thus become critical thinkers. Critical thinkers can be achieved when members in teams brainstormed and shared ideas to accomplish specific goals effectively [10].

Despite the benefits of teamwork, issues concerning teamwork are unavoidable. Issues observed such as 'free riders', lack of cooperation, inadequate rewards and conflicting task become major threats that can affect teams' performance. These problems may arise because skills and experiences amongst team members are not equally distributed amongst team members. Therefore, researchers need to investigate strategies for selecting suitable members to form effective teams.

Techniques in Team Formation: Automated tool for team formation is valuable for decision makers when assigning members to a team. Therefore, more researchers are investigating several techniques for automating group formation using computerized modeling techniques [11-14]. These techniques varied according to team characteristics under investigation. Redmond [11] used greedy algorithm to assign members in a team based on compatible time slots and student projects. The tool supports group schedule compatibility, however, the instructor still needs to check manually members in each team to ensure they the prior grade are equally distributed. Study by Doyle, *et al*. [12], introduce a web-based system for creating team in industry and academic institutions. The system used divergent and convergent algorithms to form team based on member's preferences. These preferences include time, location and experience.

Tobar and Freitas [13] proposed a rule-based team assignment tool based on students' IMS learner information package (IMS LIP) specification such as gender. The rule defined can be created and reused based on instructor's specific preferences for forming a team. Technique proposed by Ounnas, *et al*. [7, 14] used semantic web technologies and logic programming to deal with incomplete data when assigning members to a team. Most of the above techniques have problems with missing data and unidentified pattern; therefore studies are now focusing on fuzzy logic approach.

Fuzzy Logic Approach: In real world applications, solving problems always deal with uncertainty and imprecise data. Reviews of literature have shown that much research has been carried out describing technique to deals with this type of data. This could be achieved by applying rule-based approach. This approach includes association rule mining [15], rough sets [16] and fuzzy rule-based technique [17]. Association rule and rough sets techniques are more appropriate when dealing with empirical data. These techniques are more suitable when searching interesting patterns and strongest rules from complex problems. Nevertheless, fuzzy rule-based technique can deal with linguistic variables which were the case in this study. Therefore, fuzzy rule-based technique was chosen to analyse each predefined collection rules that can be employed by using Mamdani fuzzy inference system.

Zadeh [17] [18] introduced fuzzy logic for representing and manipulating fuzzy terms. He later used fuzzy algorithm for complex systems and fuzzy rules for capturing human knowledge that can formulate maps from given a input to stated a output. The mapping provides a basis for decisions or patterns to be identified. The process of fuzzy inference involves membership functions, fuzzy logic operators and if-then rules. There are two types of fuzzy inference systems that can be implemented in the Fuzzy Logic Toolbox namely the Mamdani-type and Sugeno-type. These two types of inference systems vary according to the determined output.

Mamdani's fuzzy inference method is the most commonly used fuzzy technique. Mamdani and Assilian [19] used fuzzy set theory to control a steam engine and boiler combination by synthesizing a set of linguistic control rules obtained from experienced human operators.

Researches using Fuzzy Logic approach have been applied in medical for diagnosing heart diseases [20], industry for controlling materials in steel production process [21] and automotive suspension system [22], internet shopping for assessing consumer behaviours pattern [23], decision making [24] and in education for evaluating students' performance [25-27].

Numerous studies demonstrated the ability of fuzzy logic in determining students' grade achievements [25-27]. Bai and Chen [26] used fuzzy membership and fuzzy rules for distinguishing students' grades based on the difficulty, importance and complexity of questions. Chen and Li [25] used fuzzy rules and fuzzy reasoning capability to automatically assign weightage to six (6) attributes; accuracy rate, time rate, difficulty, complexity, answer cost and importance of fuzzy rules. Montero *et al.* [27] introduced a fuzzy method to automatically evaluate teamwork based on grade homogeneity, grade improvement and attendance. This approach allows researchers to ensure equal assessment amongst members in a team.

MATERIALS AND METHODS

In this paper, fuzzy ruled-based was used to determine whether each team has equal prior academic achievements. Data from 26 software engineering (SE) teams was collected to test and evaluate the technique. This was done to ensure that every team has equal characteristic. Four input parameters were used to monitor the score of prior academic achievements. The teams' equality was evaluated using Fuzzy Inference System based on four data on members, known as membership function. Figure 1 shows the framework for this research.

Membership Function for Input Parameters: The input parameters represented the average grade of prior academic achievement for team members: 'A', 'B', 'C' and 'D'. These four parameters were known as membership functions. Each parameter was classified into four levels, which were '*Gagal*' (Fail), '*Lulus*' (Pass), '*Kepujian*' (Good) and '*Cemerlang*' (Excellent). Figure 2 shows the representation of membership function for member 'A'.

Fuzzy Rule-Based Construction: During this stage, rules construction was developed by calculating the mean value of total score for all members in the group. This was achieved by representing all membership functions by numbers. A fuzzy rule was constructed based on four levels, which were;

'Fail' = 1, 'Pass' = 2, 'Good' = 3, 'Excellent' = 4 (1)

Mean value was calculated using the formula;

$$\frac{A+B}{2}=n, \quad if \begin{cases} x>n & group\ is\ balance \\ x=n & group\ is\ average \\ x<n & group\ is\ unbalance \end{cases} \qquad (2)$$

where
A-minimum score
B-maximum score
x-total score of all members in the group

The rule was constructed by using the algorithm as shown Figure 3. This algorithm was used for determining the combination value for each team members.

Figure 4 shows a snapshot of the constructed rules calculated from the above algorithm. The rules were processed using Mamdani-style inference [19] in order to get crisp output indicating team equality.

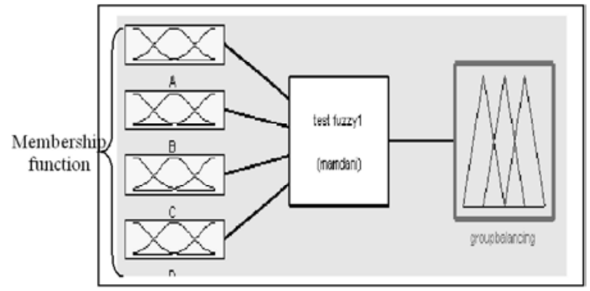

Fig. 1: Research Model

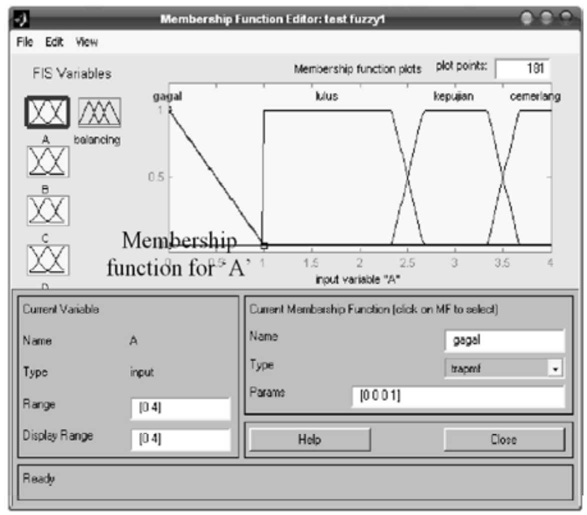

Fig. 2: Membership Functions for "A"

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for (mem1 = 1 to k) // k = 1,2,…n where n refer to total
members in a team
   for (mem2 = 1 to k)
     for (mem n-1 = 1 to k)
        for (mem n = 1 to k)
            sum = mem1 + mem2 + … + mem n-1 + mem n
              if (sum > mean value)
                   team = balance
              else if (sum < mean value)
                   team = unbalance
               else
                   team = average
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Fig. 3: Algorithm for determining the combination values of team members

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3. If (A is cemerlang) and (B is cemerlang) and (C is cemerlang) and (D is lulus) then (groupbalancing is balance) (1)
4. If (A is cemerlang) and (B is cemerlang) and (C is cemerlang) and (D is gagal) then (groupbalancing is balance) (1
5. If (A is cemerlang) and (B is cemerlang) and (C is kepujian) and (D is cemerlang) then (groupbalancing is balance
6. If (A is cemerlang) and (B is cemerlang) and (C is kepujian) and (D is kepujian) then (groupbalancing is balance) (
7. If (A is cemerlang) and (B is cemerlang) and (C is kepujian) and (D is lulus) then (groupbalancing is balance) (1)
8. If (A is cemerlang) and (B is cemerlang) and (C is kepujian) and (D is gagal) then (groupbalancing is balance) (1)
9. If (A is cemerlang) and (B is cemerlang) and (C is lulus) and (D is cemerlang) then (groupbalancing is balance) (1)
10. If (A is cemerlang) and (B is cemerlang) and (C is lulus) and (D is kepujian) then (groupbalancing is balance) (1)
11. If (A is cemerlang) and (B is cemerlang) and (C is lulus) and (D is lulus) then (groupbalancing is balance) (1)
12. If (A is cemerlang) and (B is cemerlang) and (C is lulus) and (D is gagal) then (groupbalancing is unbalance) (1)
13. If (A is cemerlang) and (B is cemerlang) and (C is gagal) and (D is cemerlang) then (groupbalancing is balance) (
14. If (A is cemerlang) and (B is cemerlang) and (C is gagal) and (D is kepujian) then (groupbalancing is balance) (1
15. If (A is cemerlang) and (B is cemerlang) and (C is gagal) and (D is lulus) then (groupbalancing is balance) (1)
16. If (A is cemerlang) and (B is cemerlang) and (C is gagal) and (D is gagal) then (groupbalancing is average) (1)
17. If (A is cemerlang) and (B is kepujian) and (C is cemerlang) and (D is cemerlang) then (groupbalancing is balanc
18. If (A is cemerlang) and (B is kepujian) and (C is cemerlang) and (D is kepujian) then (groupbalancing is balance)
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Fig. 4: Snapshot of the Constructed Rule

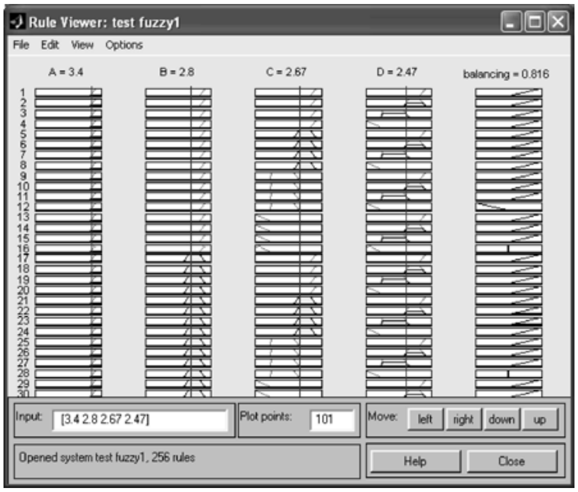

Fig. 5: Assessment of Team Equality

Fuzzy Rule-Based Evaluation: In order to evaluate the model, the real data act as the parameter and the equality characteristic of the team was calculated. The results were then compared to the real performance of each team given by project evaluators.

Figure 5 shows student A having 3.4 pointer, student B = 2.8, student C = 2.67 and student D = 2.47, the team equality characteristic was calculated as 0.816. This value (0.816) indicates the level of team equality characteristic and shows that the team has equal prior academic achievements. Therefore, the team is considered 'Fair' to undertake any project effectively.

RESULTS AND DISCUSSION

Data from 26 software engineering (SE) teams were collected to test and evaluate the fuzzy-rule based technique. From Table 1, it was discovered that all groups has equal characteristic for their prior academic achievements. This shows that all groups have an equal chance to perform effectively and therefore able to score in their project tasks. If the equality score is less than 0.5 mean value, the result indicates that the team will probably has problem proceeding with their project. It also shows that some members of the team have lower prior academic achievements. Therefore, the team will not be able to perform effectively and develop quality software application.

Team equality results were then compared with real performance results given by the instructors. Results indicated that all teams perform well in their software project. This shows that fuzzy rule-based technique is able to indicate equality team prior academic achievements amongst team members.

Table 1: Sample of Results for Team Members' Prior Academic Achievements Equality

	Members				
Team	A	B	C	D	Equality Score
1	3.33	3.46	3.4	3.2	0.818
2	3.4	3.13	3.6	2.87	0.83
3	2.8	3	2.47	2.67	0.816
4	2.73	3.07	3.67	2.67	0.837
5	3.46	3.4	3	2.4	0.818
6	3.4	2.8	2.67	2.87	0.818
7	2.67	2.63	2.7	2.53	0.814
8	2.73	3.2	3.27	3.53	0.816
9	3.73	3.67	2.56	3.6	0.823
10	3.47	3.06	3.6	2.47	0.816

CONCLUSION

This study proved that fuzzy rule-based technique can be used to solve complexity problem involving establishing whether team members have equal prior academic achievements before embarking on comparative research studies. This proved that fuzzy rule is capable for solving complexity problems such as determining whether each team contains members that have equal prior academic achievements. It is important to be able to form team with equal prior academic achievements because this will add validity and reliability of team formation. The technique can be improved to accommodate more members for each team. Further improvement is required to incorporate this technique in team formation model. By incorporating this technique in team formation model, each team can be guaranteed to have equal chances to perform effectively. This technique can facilitate decision makers when forming highly productive project teams.

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