

A Novel Approach for Agile Software Development Methodology Selection Using Fuzzy Inference System

Anand Kumar Rai
Computer Science & Engineering
Shri Ramswaroop Memorial
University
Deva Road, Barabanki, India
anandrai07@gmail.com

Shalini Agarwal
Associate Professor
Computer Science & Engineering
Shri Ramswaroop Memorial
University
Deva Road, Barabanki, India
shalini.cs@srmu.ac.in

Abhishek Kumar
Assistant Professor,
Department of Computer Science
Banaras Hindu University, Varansi
abhishek.maacindia@gmail.com

Abstract— An Agile Methodology of software development has been more popular in the software industry in terms of fast software delivery, less documentation, more satisfaction and more interactions between developers and users. In this paper Fuzzy Inference System based model is proposed to select an appropriate agile method for successful software development. A number of agile methods such as Extreme Programming (XP), Scrum, Feature Driven Development (FDD) and Dynamic System Development Method (DSDM) have been proposed in the literature. Selection of an appropriate method for a given project is a pivotal and a challenging issue. As a solution to this problem, the projects are categorized into four classes namely, Small scale, Medium scale, large scale and safety critical projects, where project size is estimated based on programmer months (PM) and the proposed model is applied to select the most appropriate agile method for each of the project category. MATLAB Simulation results reveal that the proposed model is efficient in predicting the suitability of one of the agile methods.

Keywords— Agile Methodology, DSDM, FDD, Fuzzy Inference System, Input Determinant, SCRUM, XP.

I. INTRODUCTION

Agile Methodology is based on iterative and incremental development concept in highly contributed by number of people to build high quality software in a cost and schedule efficient manner which permits the project to accept the alterations promptly. Agile methodologies give emphasis on delivering the smallest functional part of the project as soon as possible and continuously make it better and put together useful functionality throughout the project lifecycle. Agile give assistance in minimizing the whole risk and permits the project to consent to receive the changes fast. Activity is fulfilled in reiterations, which finalizes in one to six weeks. At the present time, the industry usually make a choice for agile methods which are considered much result oriented. Agile methods give emphasis on effective communication in addition to more written documents [8], [17] In Agile methods working software

the measurement of progress. Frequent delivery, less defects, continuous testing and iterative approach is the key feature of the agile methodology [1], [4], [24].

In this study, it is proposed to establish a technique using Fuzzy Inference System, so that a suitable Agile Methods can be selected amongst Extreme Programming (XP), Scrum, Feature Driven Development (FDD) and Dynamic System Development Method (DSDM) for the successful software project development. The agile methods are based on a set of philosophy, it shows the broad nature of all the other agile methodologies. The 12 principles of the formal declaration in the Agile Manifesto are given below [5], [15], [18].

- (1) Customer satisfaction by the early and constant delivery of software is the top precedence.
- (2) Changing requirements are always welcome, for the customers competitive interest agile processes bond with change.
- (3) In shorter time scale working software is delivered frequently (pair of weeks to a pair of months).
- (4) Business people and developers work together.
- (5) Motivated persons are involved to build the project, required background and support are provided they need.
- (6) It is believed that the development team face to face discussion is the most competent and efficient method of finalizing information.
- (7) It is believed that working software is the very important measurement of progress.
- (8) Agile methods are the sustainable development. The developers, sponsors and users should be able to keep up a stable pace for an undetermined period.
- (9) It is believed that continuous attention to technical quality and good design increases agility.
- (10) It is believed that the art of maximizing the amount work done is not essential for the simplicity.

(11) It is believed that by the self-organizing team the best architectures, designs and requirements successfully materialize.

(12) It is believed that team reflects the success is attained at regular intervals.

In this study the most popular agile methods XP, SCRUM, FDD and DSDM are considered for the small project, medium project, large project, very large project and safety critical projects. The Brief overview of Agile Methodology Extreme Programming (XP), Scrum, Feature Driven Development (FDD) and Dynamic System Development Method (DSDM) are as follows:

Extreme Programming (XP) was presented by Kent Beck during the working on a Chrysler payroll project in 1996. This agile method proposed to achieve better software quality and accept customer changing requirements. It recommends repeatedly "releases" in small development cycles, it is believed to improve output and bring in check barrier at which new requirements can be set up. the foundation of XP method are the pair programming, widespread code review, smooth structure of management, unit testing, code simplicity and repeatedly communication with the customer. In this method the software engineering practices are taken to "extreme" levels [2],[5].

SCRUM was introduced by Jeff Sutherland, Ken Schwaber and Mike Beedle in 1996. Scrum basically focuses on project management project management technique. It is more attentive on decision-making skills of developers and managers equally. Scrum is light weight incremental and repetitive process to develop and managing any project. Scrum implements small number of requirements in two or four weeks sprint cycles. The frequent addition and small sprint minimizing the risks. Daily Scrum meeting is controlling method for the well management of the project. Small teams including about seven to ten people [4].

Feature-Driven Development (FDD) was introduced during the project for a large Singapore bank in 1997 by Jeff De Luca. FDD was built for the domain object modelling. It comprises of five essential activities that is the overall model development, feature list structure, feature scheduling, feature design, and the feature construction. In these activities the last three activities are small repetitive practices. In this method if any feature take longer than two weeks then it needs to be broken down into small features[4][19].

Dynamic Systems Development Method (DSDM) was introduced in 1995 by the DSDM association which was created by vendors and professionals in software engineering to provide a structure for Rapid Application Development (RAD) techniques. This association developed a self-governing development on the basis of best practice experiences of those persons or groups which are working in large companies such as British Airways, American Express and Oracle. The

governing principle comprises focusing on need of industry delivering on time boxing effort, and more clearly defined association with end users, business representatives, team members, and other stakeholders [19].

In this study a novel method is proposed for the selection of an appropriate agile method amongst XP, SCRUM, FDD and DSDM according to the project nature and size [8]. This approach is entrenched using Fuzzy Inference System (FIS) which is very popular and growing area with the combination of software engineering where the input parameters are not estimated precisely. In the software engineering field most of the development parameters are not definite and very difficult to predict, for the responsible project authorities. So, there is need of an effective decision model which can predict precisely or with very less error. In this study a Fuzzy Inference System which is the part of Fuzzy logic is used. Fuzzy logic is obtain from the theory of Fuzzy set and it can be organize as a predictable logical system. In different computational and manufacturing engineering domains Fuzzy logic have been most demanding. Fuzzy logic was applied in several software engineering development phases. A structure of FIS model can be expressed by a set of fuzzy If-Then rules. It works as a theoretical supporting structure which works in the vague knowledge representation. The qualitative values like low, medium and high will be defined in the fuzzy logic, these ideas can be expressed scientifically and implemented by computers[16],[21].

FIS of the fuzzy logic, is performed in three steps which are Fuzzification of input factors, Development of fuzzy rules on the basis of qualitative values of input factors and Defuzzification is the process for the conversion of output in crisp form. The fuzzy rule base is created with help of the experienced decision maker, The fuzzy knowledge are programmed in form of: IF (a_1 is A_1 , a_2 is A_2 , a_n is A_n) THEN (b_1 is B_1 , b_2 is B_2 , b_n is B_n) where linguistic variables a_i , b_i take the value of fuzzy sets A_i and B_i correspondingly[12].

II. BACKGROUND

Agile methodologies have been progressed by adapting various principles and processes [19] the attention are paying by all agile methods on business problems and their resolutions in the small time-frame. In agile methodology trust on self-organizing team and communication is the high key concern and process is a low key concern [23], [26]. Some agile methods emphasis on more practices and others focused on management features. There are several agile methods and they have major differences in the measurement for phases of the software development life cycle. Different agile methods have the different team structure [20].

In practice, a small number of companies are capable technically to attain on agile development methods and take up them successfully in a small period a complete adaptation recurrently taking a few more years, besides this, it may be unsuitable to be completely agile in all features of maturity for

them[2], however development manager and process engineer may be uncertain in what way to discover and to adopt agile methods incrementally, in what way to make sure that the accepted method having the ability of grown-up and produce simultaneously as the development team's skills set up and in what manner to make certain with the objective of the whole development team[5].

Qumer and Henderson-Sellers (2008), created an analogous framework for estimating agile methodologies depending on their agility features. Four measurable extent framework of agile values, scope, processes and features [2]. They examine methodically six agile methods. The authors coming at the end at a grade of agility index that could shows the way of choice of an agile process for a particular project. The chain of surveys offered by researchers, discovering the position of actual application in this field, it was identify a number of factors that influence the decision of pick out the most adequate development methodology in favour of a clearly defined project [4],[16].

Table 1. List of Agile method Determinant

S.N.	Input Determinant	Abbreviation
1	Project Size	PS
2	Requirement Uncertainty	RU
3	Cost and Schedule Flexibility	CSF
4	Software Criticality	SC
5	Project Complexity	PC
6	Reusable Component	RC
7	Team Size	TS
8	User Involvement	UI
9	Development Flexibility	DF
10	Team Cohesion	TC

Another study evaluated the agile risk factors to uncover which agile method is the most appropriate determined by grade of the factors for a clear and detailed project. The consequences of this research are supportive for the developers by serving them to categorize what agile software development methodology can be used with success for a detailed project [6].

Agile methods have develop into an attractive substitute for companies motivated to get better their performance, while the agile methods previously considered for small and individual teams, this makes unusual challenges at the same time presenting agile at scale, when development teams must coordinate their actions, and there might be a requirement to boundary with other organizational units[9].

III. MAIN FOCUS OF THE PAPER

There is some uncertainty involved software engineering activities later these cause problems in several ways to software projects. Several risks and assumptions are associated with software projects. Fuzzy logic approach is a very suitable approach to solve the software engineering issues in many ways. In this study selection of appropriate agile methodology for the proposed project is also encompasses of some of the

uncertainty, therefore fuzzy logic approach can be help in making decision for selection of suitable agile methodology during the preliminary phase of the software development and succeed in dealing with the indecisive problem. The aim of this study is to identify the agile method selection determinant and to help organizations, what software development methodology should be used for projects to easier delivering projects within schedule, within cost and fulfil all the project requirements. During this research only four methodologies are considered for study. Extreme Programming (XP), SCRUM, Feature Driven Development (FDD), and Dynamic System Development Method (DSDM) using the fuzzy inference logic [14],[20],[21].

IV. FUZZY INFERENCE SYSTEM BASED PROPOSED MODEL

To determine the appropriate agile methods amongst XP, SCRUM, FDD and DSDM, The major factors which play an important role in agile software development are considered as agile project input determinant[11],[13],[19],[22],[25],[27]. The list of agile software development determinants are shown in Table 1. This study is based on analytical processes. These processes are shown in Figure 1, The 10 agile method selection determinants were identified which are more decisive in selecting an appropriate agile methodology. On the basis of 10 project determinants and previous successful selection of agile methods case study is considered, in making the fuzzy rule base. On the basis of related literature review 10 fuzzy fule base is created [2],[3],[6],[7],[14], which is shown in given Table 2. In this study Fuzzy Inference System (FIS) Mamdani Rule is applied. To compute the output of the FIS one must go through the following steps [10], [21].

- 1-Creating a set of fuzzy rules.
- 2-Fuzzifying the inputs using the input membership functions.
- 3-Combining fuzzy rule base value of input determinant and defuzzifying the Output.

Step-1 Creating a set of Fuzzy Inference rules

The fuzzy rule base is created on the basis of previous study and successful agile projects completed under the most suitable project environment for the agile methods XP, SCRUM, FDD and DSDM. The qualitative value project determinants are given in Table 2. On the basis of Table 2, the fuzzy inference rules are created and implemented through MATLAB simulator (Fuzzy Inference Editor) to produce the results on input determinant value.

Step2- Fuzzifying the Inputs Using the Input Membership Functions

In this study, triangular function is used to represent the low, medium, high area which is shown in Figure 2. Fuzzy membership function range from 0 to 1 and Input/output range from 0 to 1. Further, input/output elements lay into three qualitative values, low, medium and high. Low membership triangular function range from 0 to 0.4, Medium membership triangular function range from 0.1 to 0.9 and high membership triangular function range from 0.6 to 1[10].

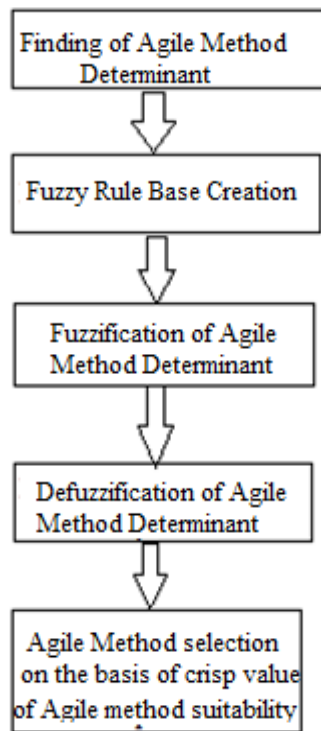


Figure 1. Proposed model of Agile method selection

Table 3, shows the numerical values of the fuzzy membership function which is achieved by interpolation of the graph shown in Figure 2, Although MATLAB fuzzy simulator generate fuzzy membership value of input determinant very precisely at any point of triangle relative low, medium, high. The input determinant and output agile methods qualitative value (LOW, MEDIUM and HIGH) strength can be quantify using this concept(Leary Tomlin et al., 2016; R.V. Rao, 2009). Figure 3, shows the FIS relation with input determinants and outputs agile methods to be used. In this study, to find appropriate agile methods amongst XP, SCRUM, FDD and DSDM, Mamdani FIS is applied on created fuzzy rule base. Finally aggregation (Max Method) and Centroid method is applied for the defuzzification Process to find the quantitative values of agile methods suitability.

Step-3 Combining fuzzy Rule Base Value of Input Determinant and Defuzzifying the Output

Using the conjunction operator (AND) in the antecedents of the rules the rule firing weight is calculated, finally to find the fuzzy rule strength the aggregation method applied (combining fuzzy rule), and defuzzification process performed using Center Of Gravity(COG) which is also known as Centroid method.

$$\text{Center of Gravity} = \frac{\sum_i^n x_i A_i}{\sum_i^n A_i} \quad \text{Eq.1 Where } x_i = \text{fuzzy membership value, } A_i = \text{input determinant value.}$$

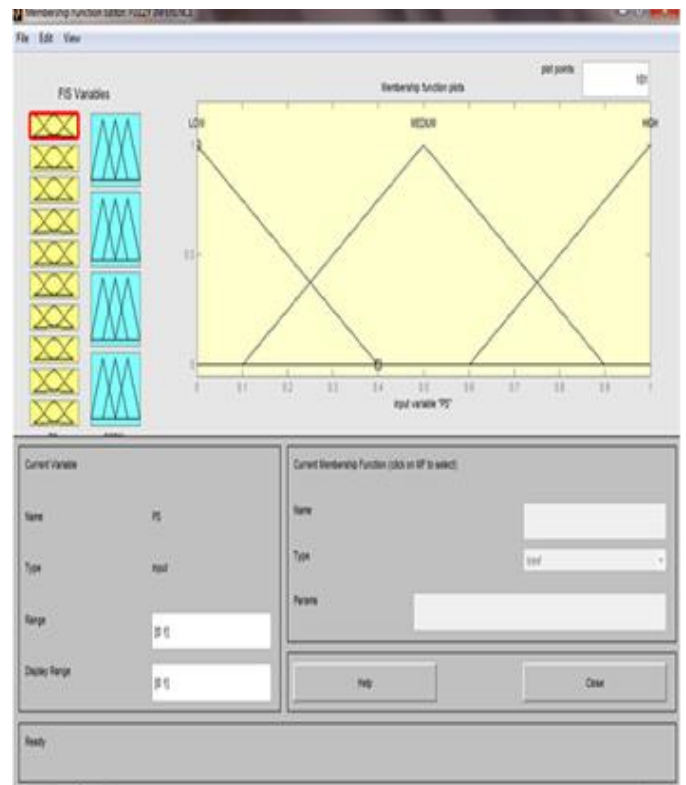


Figure 2. Fuzzy membership functions for the input determinant agile methods(XP, SCRUM,FDD,DSDM)

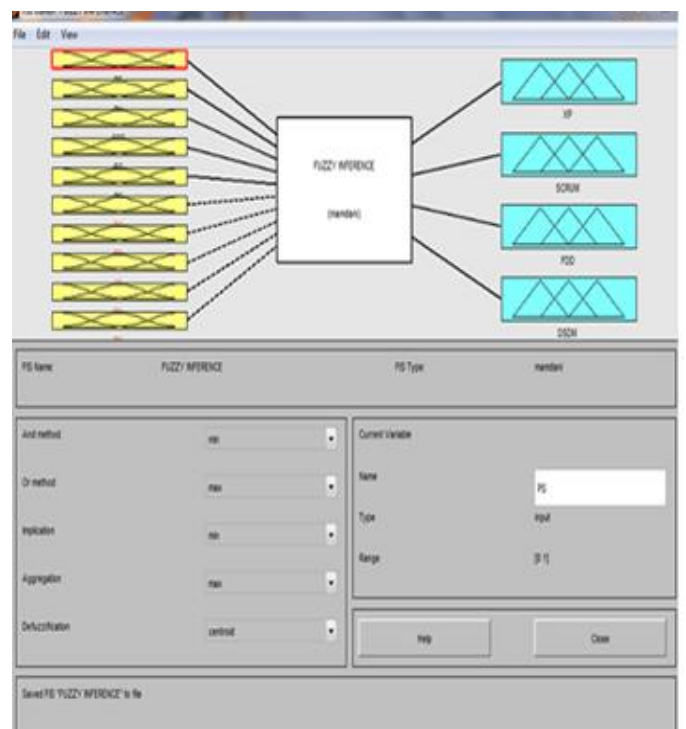


Figure 3. Fuzzy Inference System(Mamdani rule)

Table 2. Fuzzy Rule Base for the appropriate Agile Method Selection

Agile Software development selection method Determinant (Input)											Agile method suitability			
Rule	PS	RU	CSF	SC	PC	RC	TS	UI	DF	TC	XP	SCRUM	FDD	DSDM
1	L	H	M	L	L	M	L	H	M	M	H	L	L	L
2	M	M	M	L	M	H	M	H	H	H	H	L	L	L
3	M	M	L	L	M	M	L	M	H	H	H	M	L	L
4	M	L	L	M	M	L	L	L	L	H	M	H	L	L
5	H	M	M	M	H	M	M	M	M	H	L	H	M	L
6	H	M	L	L	H	L	L	L	M	H	L	H	L	L
7	H	L	L	L	H	M	H	L	M	H	L	L	H	L
8	H	M	M	M	H	H	H	M	L	M	L	L	H	L
9	H	H	M	H	H	L	L	H	M	H	L	L	L	H
10	H	M	L	H	M	L	M	M	L	H	L	M	L	H



Figure 4. Fuzzy rule base for finding the appropriate agile method

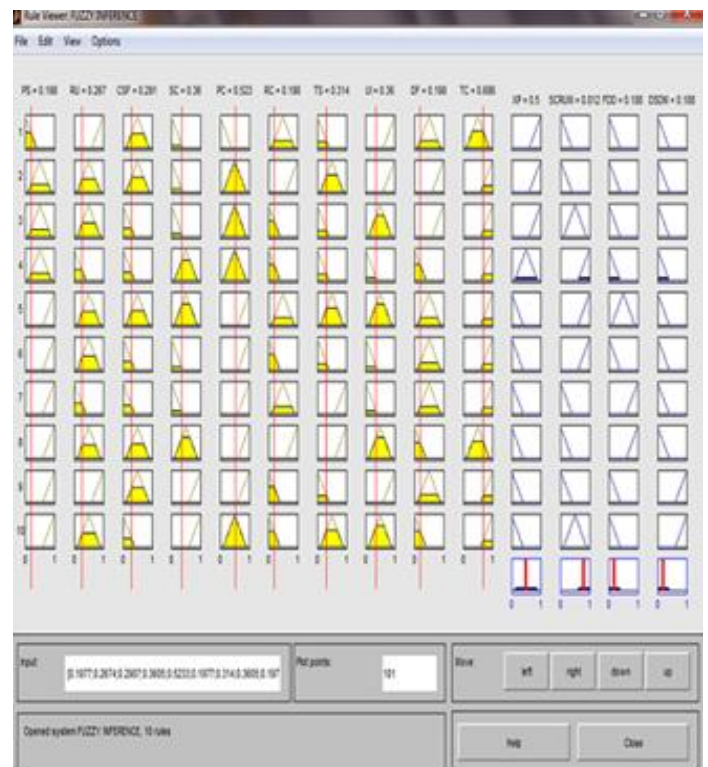


Figure 5. Rule view of Input /Output functions

Table 3 Fuzzy Membership Function for the Input Determinant

S.N.	Input Scale	Low	Medium	High
1	0.1	0.75	0	
2	0.2	0.5	.25	
3	0.3	0.25	0.5	
4	0.4	0	0.75	
5	0.5		1.0	
6	0.6		0.75	0
7	0.7		0.5	.25
8	0.8		.25	0.5
9	0.9		0	.75
10	1.0			1.0

V- RESULTS & DISCUSSION

To evaluate the more precise value of input determinant (agile method selection project factors) and output agile methods, MATLAB Fuzzy Inference Editor is used. Figure 4, shows the fuzzy rule base using fuzzy inference system to finding the most appropriate agile method. Figure 5, Shows the rule viewer of input output functions. The rule viewer vertical line on input determinant can be shifted on desired position and this gives the membership function value of input determinant. On the basis of input determinant membership value the output strength of agile methods are produced through fuzzy rule base. The centroid defuzzification process is used to produce the crisp result of output. This value is also verified by manual calculations, with the help of Eq.1. Putting the vertical lines of input determinant in the rule viewer on different positions, it predicts output (Agile Methods) strength precisely after the three digits of decimal sign. The input/output samples are taken from the rule viewer for the analysis purpose. The result samples are shown in Table 4; it describes the agile methods strength on different input determinant value. The graphical representation of result is shown in Figure 6, result shows the fuzzy rule base Input determinant and output agile methods strength. As the study suggests that agile methods SCRUM and XP have very high rule strength [15], [16].

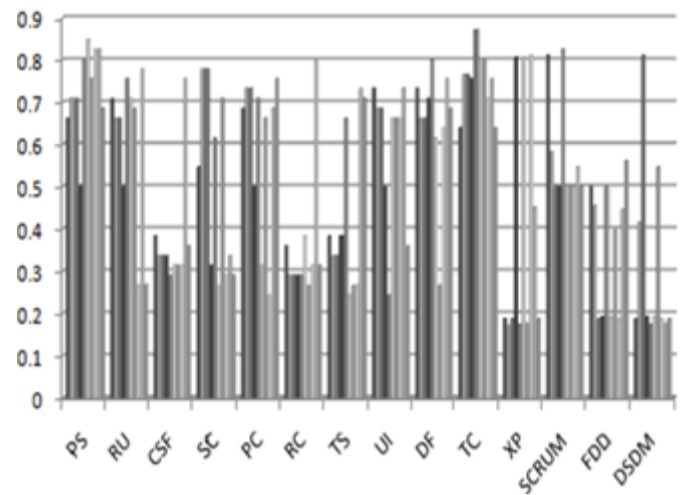


Figure 6. Agile methods suitability graph

These two methods are used in general cases and the rest methods are used in specific cases. Practically it was seen that SCRUM and XP methods are more popular in industry and FDD, DSDM methods are used in specific circumstances whereas DSDM is used for very large and safety critical projects Study suggests that agile team cohesion strength must be more than 0.6 and other input determinant may vary massively in case of different method selection. Practically it was seen the team cohesion is necessary condition to use agile methods [11], [26].

VI. FUTURE RESEARCH DIRECTIONS & LIMITATIONS

This study is based on 10 software agile method determinant this determinant can be enhanced in future for more accurate decision. In this study 10 Fuzzy Rule Base is created for suitable Agile Method selection, this Fuzzy Rule Base can be enhanced as well. To choose the desired method a learning method can be developed. This method predicts only agile methods suitability on the basis of existing input determinant strength. Learning method can also predict the, what method the development team/system manager would like to use and what the input determinant strength must be fixed. To develop the AI based learning method this study may prove very useful.

This research is conducted for agile software development methodology, there are several agile methods available, but to select the suitable method amongst them is a very complicated task for the Project Manager. This research is conducted for XP, SCRUM, FDD and DSDM agile methods, for small scale, medium scale, large scale and safety critical software projects.

Table 4 Input Determinant and Output crisp value based on Fuzzy Rule Base

Agile Software Determinant as Input Variable											Sustainability of Agile Methodology			
S.N	PS	RU	CSF	SC	PC	RC	TS	UI	DF	TC	XP	SCRUM	FDD	DSDM
1	0.663	0.709	0.384	0.547	0.686	0.360	0.384	0.733	0.733	0.640	0.188	0.812	0.500	0.188
2	0.709	0.663	0.337	0.779	0.733	0.291	0.337	0.686	0.663	0.766	0.172	0.583	0.456	0.417
3	0.709	0.663	0.337	0.779	0.733	0.291	0.337	0.686	0.663	0.766	0.188	0.500	0.188	0.812
4	0.50	0.500	0.337	0.314	0.500	0.291	0.384	0.500	0.709	0.756	0.807	0.500	0.193	0.193
5	0.802	0.756	0.291	0.616	0.709	0.291	0.663	0.244	0.802	0.872	0.174	0.826	0.500	0.174
6	0.849	0.709	0.314	0.267	0.314	0.384	0.244	0.663	0.616	0.802	0.807	0.500	0.193	0.193
7	0.756	0.686	0.314	0.709	0.663	0.267	0.267	0.663	0.267	0.802	0.177	0.500	0.399	0.548
8	0.826	0.267	0.314	0.291	0.244	0.314	0.267	0.663	0.640	0.709	0.812	0.500	0.188	0.188
9	0.826	0.779	0.756	0.337	0.686	0.802	0.733	0.733	0.756	0.756	0.452	0.548	0.447	0.177
10	0.686	0.269	0.360	0.291	0.756	0.314	0.709	0.360	0.686	0.640	0.188	0.500	0.562	0.188

VII. CONCLUSION

In this paper we have evaluated the selection sustainability of agile methodologies viz. XP, SCRUM, FDD, DSDM for the fulfillment of requirements in completing a software project. To perform this task, ten agile software determinant were collected from literature review based on previous studies which are effective in agile methods selection sustainability. Then we have created a fuzzy rule base on the basis of agile software determinant strength and further implemented through MATLAB Fuzzy Inference System, which evaluates all the factors that may affect the selection choice of a methodology. Each factor is defined by membership functions and ten different rules based on 'if-then' conditions. The quantified result shown in Table 4, since, the input/output values are crisp in nature so, it possibly will very helpful for adapting and using appropriate agile methods on the basis of project environment. In future the number of inputs determinants may be enhanced and few more Fuzzy Rule Base can be created for more accuracy which actually affects the selection suitability.

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