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Website Tenders Evaluation Using Fuzzy Logic

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ABSTRACT

Developing a new website for a government institution is one of common tenders issued by various ministries and government institutions in the world. The country of Jordan usually has at least 22 different ministries and government institutions at a given time. Each one of these entities has its official website which is revamped every three years because of the rapid changes in information and technology. In most cases the ministries and institutions issue a tender to the public, then after collecting tender offers from different companies, only one offer would be selected. The selection process would choose the most appropriate contractor to deliver the project with respect to quality, time and cost. This article presents a new fuzzy logic system for tender evaluation which is based on both the technical qualification of the bidder company and its experience. The proposed system has shown better performance evaluation when compared to the traditional evaluation method currently used by the government.

KEYWORDS

Fuzzy Controller Logic (FIC), Mamdani Model, Tender Evaluation, Tender for Website Development

1. INTRODUCTION

In Jordan, at least 22 different ministries and government institutions are available at a time. Each one of these entities has its official website which is improved at least every three years because of the rapid changes in information and technology. In most cases the ministry or institution would issue a tender to the public for revamping its website. Once the tenders are submitted then the evaluation process would start to select one winner bidder. Ministries in Jordan have realized for some time that the lowest price bid is not always the best choice. In many cases the quality of the proposed services, products or projects is not necessary met by the lowest bidder. This has been noticed in the past with different tender types, including hardware equipment, software, services, building construction, etc.

Many approaches for tenders' evaluation do currently exist. The most common one is to have a mathematical equation which relies on weighted criteria or factors, that not only depends on the price but also have factors related to quality, such as company experience, new technologies used, project management, risk managements and other factors.

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(Liu & Lai, 2000) have shown that evaluations that depends on price only have bad results. That is because it will ignore the importance of other attributes, such as quality, experience, performance, time, safety, and others. Liu have presented a multi attribute model based on weighted mathematical equation. The major selected attributes were as follows: safety, time, quality and cost.

Besides using equation of multi weighted criteria, fuzzy logic was introduced in many ways in tenders' evaluation because most of the criteria used in evaluation are qualitative in nature. This makes using fuzzy approach more suitable for this kind of evaluation.

Many fuzzy logic-based models were applied to tender evaluation in building construction and engineering projects (Zhang, 2015; Liu & Lai, 2000; Nguyen, 1985; Hsieh, Lu & Tzeng, 2004; Jianxiang, 2010; Morote & Vila, 2012; Bendana, Del Cano & De La Cruz, 2004). A model for engineering project tender evaluation based on fuzzy Data Envelopment Analysis (DEA) and grey relational analysis have been presented (Zhang, 2015; Shen & Li, 2005; & Huang & Qiu, 2003). The presented model has used fuzzy synthetic assessment and DEA for qualitative indicators such as Project Quality, Construction Technology and Corporate Reputation. The following linguistic values in the assessment: very poor, poor, medium, good, and excellent have been used by (Zhang, 2015). The grey system theory for quantitative indicators that were actually cost indicators such as Project Quotation (in million-yuan) and Project Duration (in Days) have also been used by (Zhang, 2015). (Zhang, 2015) not only have shown how it is useful to evaluate the tenders based on qualitative and quantitative indicators but also found the reasons for ineffectiveness of bad bidders.

A fuzzy and multi-criteria model for tender evaluation have been proposed by (Nguyen, 1985; Brown & Yao, 1983). The proposed model has depended on the following three main criteria: cost, past experience of tenderers and present bid information.

A model for selecting alternatives for planning and design (P&D) in public office building have been presented by (Hsieh et al., 2004; Altrock & Krause, 1994; Baas & Kwakernaak, 1997; & Chang & Chen, 1994). First, the model has included the following three interest groups: owners, users and expert representatives. The model has used the Fuzzy Analytic Hierarchy Process (FAHP) to calculate the weight factors to each interest group. Second, it did use Fuzzy Multiple Criteria Decision Making (FMCDM) to represent group decision. (Hsieh et al., 2004) has effectively simplified the complicated multi-criteria and fuzzy perception problem of selecting alternatives for building P&D.

A framework for tender evaluation of infrastructure projects of institutions of higher education in China have been presented by (Jianxiang, 2010; & Guoyin, 2001). It did use rough set theory to evaluate the tender based on the following variables: price indications, quality indicators, production and technical indications and project progress indicators. Rough set theory is a theoretical method used to represent incomplete and uncertain knowledge, data expression, and data study and data induction. It is also used to study object set that is described by multi-valued property.

A bidder qualification model for building projects using fuzzy set theory which handles the inconsistencies in the performance evaluation of bidders according to qualitative and quantitative criteria have been presented by (Morote et al., 2012; & Jaskowski, Biruk, & Bucon, 2010). The selected criteria that were used are the following: technical capacity, company past experience, management capability, financial stability, performance of similar projects, the quality of health and safety policy. The model have generated a hierarchical structure of criteria in order to define the weights for each criteria, then calculated the performance value for the contractors.

Several researchers have dealt with contractors' selection system based on fuzzy control (Bendana et al., 2004; & Pack, Lee, & Napier, 1992). The system was used in the private sector, in the traditional design-bid-build projects. The system has included an estimation for several qualitative and quantitative criteria. The system has used the following three different selection policies: cost, time, and quality.

A fuzzy logic framework to help decision-makers evaluate tenders of building projects have been presented by (El Agroudy, Elbeltagi, & El Razek, 2009). A fuzzy logic model was developed to build a framework for contractor selection to evaluate contractors against vague qualitative criteria.

A fuzzy logic algorithm to help individuals find a job by setting individual preferences as fuzzy linguistic input values and searching the data for the best job options have been used by (Chen, Su, Tu, Lin, & Chang, 2016).

Two fuzzy evaluation systems have been presented by (Benson, Zhang, Reid, & Dickson, 2000). The evaluation systems are automated and results indicate that fuzzy logic was able to correctly classify the decision making output.

Table 1 summarize the different approaches for tender evaluation based on fuzzy logic.

Fuzzy approaches would usually be more efficient than traditional methods. Fuzzy models show how useful is it to evaluate the tenders based on linguistic values for qualitative and quantitative indicators.

Most of the available tender fuzzy evaluation work available in literature is related to construction projects in both public and private sectors. No application was found that uses fuzzy and even non-fuzzy approach to evaluate other type of tenders in the available literature.

In this article, a fuzzy logic controller (FLC) based on the Mamdani inference engine to evaluate the website tenders for ministries and government institutions in Jordan is be presented. Section 2 describes the current approach in evaluating the website tenders in Jordan. Section 3 presents a brief description for FLC and the Mamdani inference engines and presents the proposed fuzzy model. Section 4 presents experiments and the results. The conclusion and future work is presented in section 5.

Table 1. Fuzzy solution for tender evaluation

Author	Type of Tender	Fuzzy Approach	Mechanism
(Zhang, 2015)	Engineering projects	Fuzzy Data Envelopment Analysis (DEA)	It did distinguish between indicators of evaluating both qualitative and quantitative indicators.
(Nguyen, 1985)	---------	Fuzzy set theory and multi-criteria modelling	It depends on three main criteria: cost, past experience of tenderers, and present bid information.
(Hsieh et al., 2004)	Public office building	Fuzzy Analytic Hierarchy Process and Fuzzy Multiple Criteria Decision Making (FMCDM)	Has weights for criteria of interest groups; owners, users and experts.
(Jianxiang, 2010)	Infrastructure projects of institutions of higher education in China	Rough Set Theory	Divided the indications of evaluation to price indications, quality indicators, production and technical indications and project progress indicators.
(Morote et al., 2012)	Building projects	Fuzzy Set Theory	Qualitative and quantitative criteria. The selected criteria are: technical capacity, company past experience, management capability, financial stability, performance of similar projects, the quality of health and safety policy.
(Bendana et al., 2004)	Private sector building projects	Using fuzzy control	The system used three different selection policies: cost, time and quality.
(El Agroudy et al., 2009)	Building projects	Fuzzy logic framework based in neural network	Qualitative criteria.
Our new Approach	Website Development Projects	Mamdani based Fuzzy Logic Controller (FLC)	Qualitative criteria.

2. THE CURRENT APPROACH IN WEBSITE TENDERS EVALUATION IN JORDAN

Currently the evaluation of most government tenders in Jordan regardless of their type are based on two stage evaluations; technical evaluation and financial evaluation.

Regarding website tenders, the technical evaluation usually accounts for 80% of the total score of the evaluation, and the financial evaluation accounts for 20% of the total evaluation. In order for the bidder to be considered for the final bidding stage, the bidder must have at least 65% of the total score from the technical evaluation.

Once the bidder has passed the first stage, then all passed bidders will be competing for the lowest financial bid in the second stage. So, a bidder who has passed stage one with 65% will get the bid if it has the lowest financial bid even if another bidder has the full technical evaluation (80%) and had a higher financial bid with less than 1%. This is currently the way and regulation in Jordan. Before the evaluation of tenders, it must be understood that all tenders are subject to the supplies regulation number 32 for the year 1993 and the tender instructions issued in the year 2008 and their amendments. The tender instructions include a set of conditions that each company must share and satisfy to show competencies such as the company should have legal valid registration certificate from Jordan Chamber of Commerce (JOCC) and the bidder should submit Bid Security (Tender Bond) and other conditions (MOICT, 2016).

The Two Stage Bidding Process in Jordan is as follows:

Stage One: In the technical evaluation, all offers are evaluated against a predefined criteria that is calculated using the following technical evaluation equation (Equation (1)):

Technical evaluation = 0.3 * (Technical Qualification) + 0.3 * (Company Experience)
+ 0.2 * (Design Simplicity) + 0.1 * (Project Management Approach)
+ 0.1 * (Operation Support and Maintenance) (1)

At the end of this stage only the bidders who have at least 65% will pass to the next stage.

Stage Two: In this stage, only those bidders that have passed the technical evaluation will have their financial offers reviewed. The winning proposal will be selected on the basis of "Lowest best evaluated value that have passed the technical evaluation". The financial offer of those who do not qualify will not be opened and will be returned to the bidders.

In this stage the financial evaluation will be calculated according to Equation (2) as follows:

Financial evaluation = Minimum Price from passed offers / Company offer (2)

The final Equation (3) is used to calculate the total score for a tender evaluation as follow:

Final Evaluation = 0.8 * Technical evaluation + 0.2 * Financial evaluation (3)

It is clear that the duration of the project is not part of the evaluation because the duration in a government project related to website development has a predetermined period which is usually 70-90 calendar days and there is no way for the bidders to go around this requirement. In most previous bidding cases there was no bidder that has been offered to perform a job with less time than the specified in the tender. Table 2 shows an example of a current tender evaluation.

Table 2. Example for current tender evaluation

	Price in JD	Technical Evaluation	Pass >= 65	Technical (80%)	Financial (20%)	Final Evaluation
Offer 1	6000	93	93	74.40	13.33	87.73
Offer 2	5000	87	87	69.60	16.00	85.60
Offer 3	3450	60	---	---	---	---
Offer 4	5500	55	---	---	---	---
Offer 5	4000	72	72	57.60	20.00	77.60

Min Price = 4000

In the previous example, according to Equation (3), offers 1, 2 and 5 will pass to the next stage (stage two), so only their prices will be evaluated. The cost of offers 3 and 4 will not considered since they did not pass the technical evaluation. So offer 5 will got the full mark (20) for the financial evaluation and will be given the tender. Even though offer 1 has the highest evaluation and offer 5 has the lowest evaluation, still offer 5 was given the tender. It is clear that there is a need to have a new and efficient approach for tenders' evaluation for website development projects for the various Jordanian minsters.

3. THE NEW FUZZY LOGIC PROPOSED SYSTEM FOR WEBSITE TENDER EVALUATION

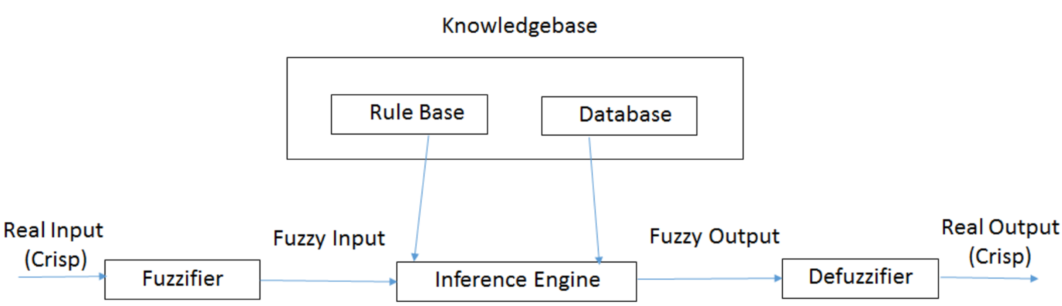
In this section, a new tender evaluation system will be proposed. The proposed system uses fuzzy logic since tender evaluation inputs can be very subjective and ambiguous. The proposed system will be a fuzzy logic controller (FLC) that has the architecture which is shown in Figure 1.

The FLC has four basic components which are: fuzzifier, inference engine, Knowledgebase and defuzzifier. The fuzzy rules are conditional statements which have the following format:

If (ANTECEDENT) Then (CONSEQUENT)

These rules will encompass the inference engine to produce the fuzzy output. The fuzzifier will map the crisp (real) input values to fuzzy values before entering the inference engine. After firing the rules, which depends on the fuzzy inputs, the outputs will be aggregated to form a single fuzzy output. Finally, the defuzzifier will map the fuzzy output to a crisp (real) output.

Figure 1. The FLC architecture



Inference engines are of three types (Dadios, 2012): (1) Mamdani Model, (2) Takagi-Sugeno-Kang (TSK), and (3) Kosko's additive model (SAM). The proposed solution will be based on Mamdani model which is the most commonly used fuzzy inference technique (Dadios, 2012).

The proposed Fuzzy Logic System in this paper was implemented using Matlab. Three steps are involved during the implementation of the fuzzy model, which are as follows:

1. Fuzzification of input and output variables;
2. Definition of Fuzzy Rules for the fuzzy logic system and inference engine;
3. Defuzzification of fuzzy output value to crisp output value.

The proposed Tender Fuzzy Evaluation model is shown in Figure 2.

3.1. Fuzzification of Input and Output Variables

The website tender evaluation system has five inputs which are the following: Technical Qualification (TEC-QUL), Company Experience (COM-EXP), Simple website design (SIM-DES), Project Management Methodology (PM) and Operation Support and Maintenance (SUP). The system also has one output which is Technical Evaluation. All input criteria are qualitative. Table 3 shows the list of all inputs and output linguistic variables and their linguistic values.

The linguistic variables for all inputs and output will be fuzzified according to linguistic values using triangle functions. Figures 3 through 8 shows the membership function for all inputs and output variables.

3.2. Fuzzy Rules for the Fuzzy Logic System

Fuzzy sets and fuzzy operators are used to formulate the fuzzy logic rules. The If-Then rule form is used to formulate the condition statements that comprise the fuzzy logic. The If-Then fuzzy rules have the power to perform inference under partial matching. The If-Then fuzzy rules have the following format:

If (ANTECEDENT) Then (CONSEQUENT)

Figure 2. The proposed fuzzy evaluation model

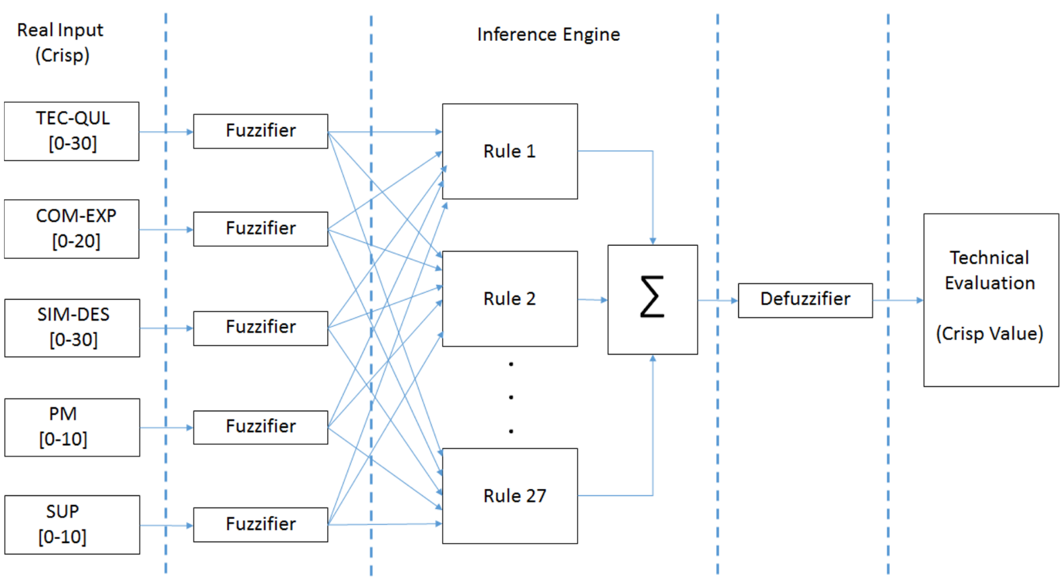
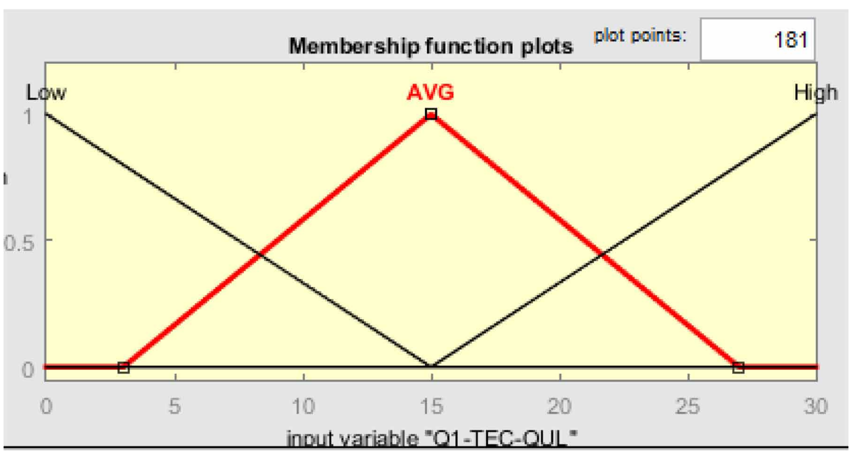


Table 3. Inputs and output of fuzzy system

Att	Abbreviation	Input/Output	Crisp Values	Description	Linguistic Values
Q1	TEC-QUL	Input	[0-30]	Technical Qualification	{Low, Average (AVG), High}
Q2	COM-EXP	Input	[0-20]	Company Experience	{Low, Middle, High}
Q3	SIM-DES	Input	[0-30]	Simple website design	{Complex, Fair, Ease}
Q4	PM	Input	[0-10]	Project Management Methodology	{Strong, Acceptance, Weak}
Q5	SUP	Input	[0-10]	Operation Support and Maintenance	{Low, Middle, High}
Q6	Technical Evaluation	Output	[0-100]	Technical Evaluation Value	{Very Low, Low, Average (AVG), High, Very High}

Figure 3. Membership values for the linguistic input variable Q1-TEC-QUL



All inputs will be part of the ANTECEDENT: Q1-TEC-QUL, Q2-COM-EXP, Q3-SIM-DES, Q4-PM and Q5-SUP. The antecedents are calculated to resolve the CONSEQUENT as a single fuzzy output (Technical Evaluation) using the AND operator.

The maximum numbers of rules that can be used are 243 rules, but with the help of an expert in this area only 27 fuzzy rules were needed for this application. Table 4 shows the set of rules that were selected for this application.

3.3. Defuzzification of the Fuzzy Output to Get a Crisp Output

The Mamdani inference engine has been used to implement the proposed FLC. The composition inference rule with sup-min operator will be used to calculate the fuzzy output which will be the result of firing the appropriate rule(s) based on the inputs. The set of outputs will be aggregated

Figure 4. Membership values for the linguistic input variable Q2-COM-EXP

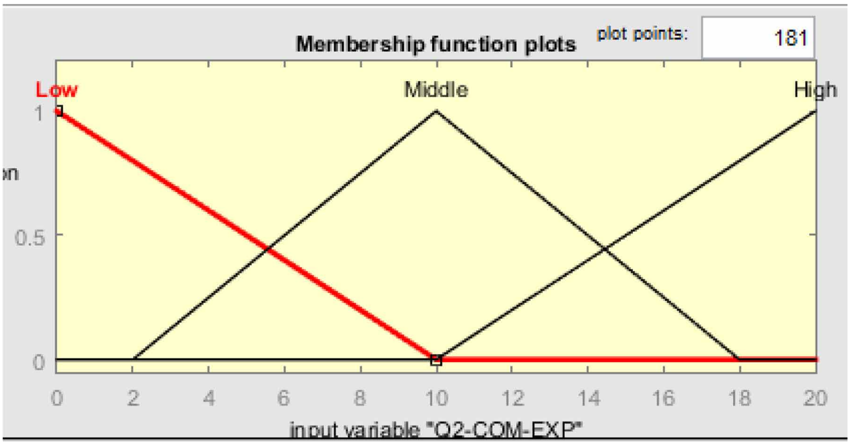


Figure 5. Membership values for the input variable Q3-SIM-DES

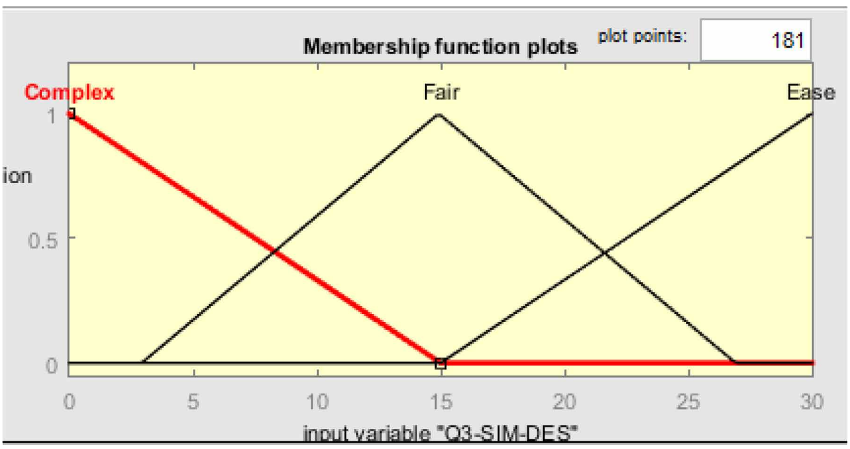


Figure 6. Membership values for the input variable Q4-PM

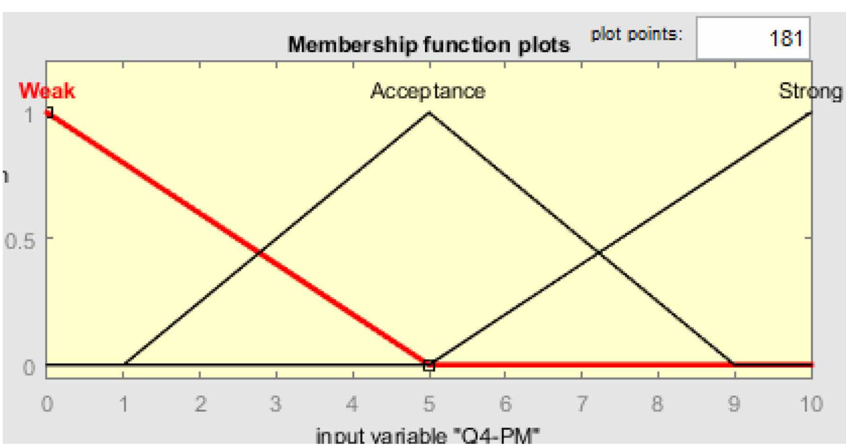


Figure 7. Membership values for the input variable Q5-SUP

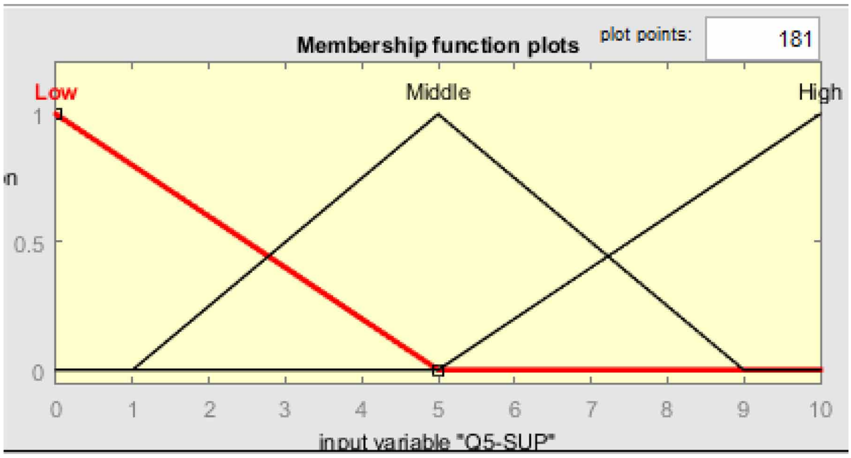
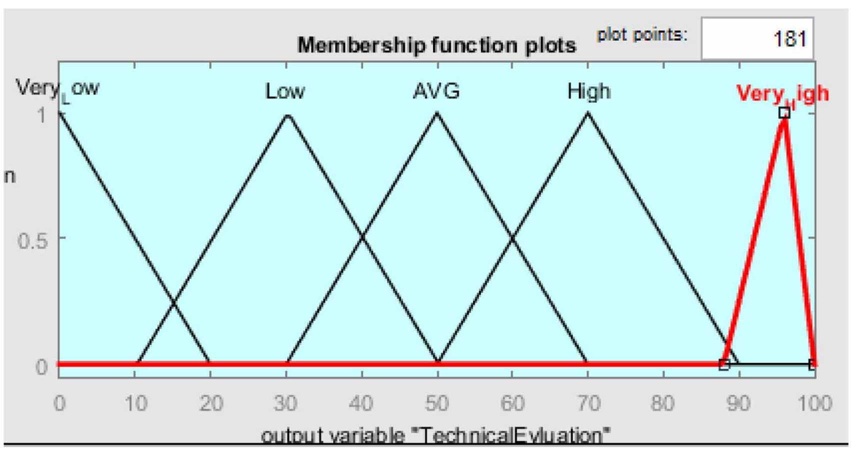


Figure 8. Membership values for the output Technical Evaluation



using the max operator. The fuzzy output will then be defuzzified using the centroid method. The centroid defuzzification method returns the center of area under the curve according to the following equation:

$$z^* = \frac{\int \mu_c(z) z dz}{\int \mu_c(z) dz}$$

where $\int$ denotes the algebraic integration. The centroid method is faster, easier and gives fairly accurate result than other defuzzification methods.

There are many other methods that can be used for defuzzifying the fuzzy output to crisp output, methods such as bisectors, MOM and SOM (Dadios, 2012). Results in section 4 will show that the defuzzified output for each of these methods will be presented and it will show that the best defuzzification methods in terms of accuracy are the centroid and the bisector.

Table 4. The 27 rules used for the proposed system

Rule #	Fuzzy Inputs					Fuzzy Output
	TEC-QUL	COM-EXP	SIM-DES	PM	SUP	Technical Evaluation
Rule 1	Low	Any	Any	any	any	Very Low
Rule 2	Average	Any	Complex	any	any	Low
Rule 3	Average	Middle	Fair	any	any	Low
Rule 4	Average	High	Fair	Weak	any	Low
Rule 5	Average	High	Ease	Weak	any	Low
Rule 6	Average	High	Fair	Acceptance	Low	Low
Rule 7	Average	High	Ease	Acceptance	Low	Low
Rule 8	Average	High	Fair	Acceptance	Middle	Average
Rule 9	Average	High	Fair	Acceptance	High	Average
Rule 10	Average	High	Ease	Acceptance	Middle	Average
Rule 11	Average	High	Ease	Acceptance	High	Average
Rule 12	High	Low	Fair	Acceptance	Middle	High
Rule 13	High	Low	Fair	Acceptance	High	High
Rule 14	High	Middle	Fair	Acceptance	Middle	High
Rule 15	High	Middle	Fair	Acceptance	High	High
Rule 16	High	Low	Ease	Acceptance	Middle	High
Rule 17	High	Low	Ease	Acceptance	High	High
Rule 18	High	Middle	Ease	Acceptance	Middle	High
Rule 19	High	Middle	Ease	Acceptance	High	High
Rule 20	High	High	Fair	Acceptance	Middle	Very High
Rule 21	High	High	Fair	Acceptance	High	Very High
Rule 22	High	High	Ease	Acceptance	Middle	Very High
Rule 23	High	High	Ease	Acceptance	High	Very High
Rule 24	High	High	Fair	Strong	Middle	Very High
Rule 25	High	High	Fair	Strong	High	Very High
Rule 26	High	High	Ease	Strong	Middle	Very High
Rule 27	High	High	Ease	Strong	High	Very High

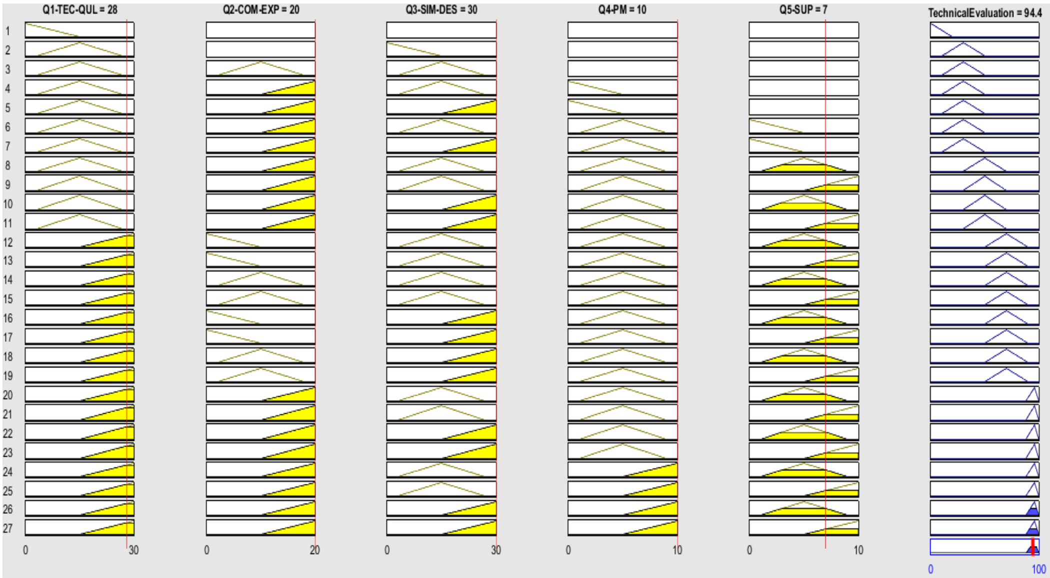
Figure 9 shows an example of the defuzzification of a fuzzy output using the rule viewer of the fuzzy inference system (FIS) editor in Matlab. The example shows the result for Tender 1, offer 4 with input vector = (28; 20; 30; 10; 7) as shown in Table 5.

4. RESULTS AND DISCUSSION

The proposed FLC module for website tender evaluation will be tested using the following two methods:

1. Testing Technical Evaluation FLC module based on real data;
2. Testing Technical Evaluation FLC module based on fabricated data.

Figure 9. An example showing the defuzzification of fuzzy output through the rule viewer of FIS



4.1. Testing Technical Evaluation FLC Module Based on Real Data

The proposed FLC model for website tender evaluation was tested on five different tenders from Jordanian ministries and government institutions. Tables 4 through 9 will show the Technical Evaluation value calculated based on equation number (1) (Actual Evaluation) and the value of the proposed FLC Technical Evaluation for each tender.

Table 5 shows the result of the first stage of evaluation for tender #1. According to the evaluation rules, only offers that have scores over 65 will pass to stage two. As shown in Table 5, the result of both approaches, the current using Equation (3) and the proposed fuzzy algorithm, will have the same results for offers 1, 2, 4 and 5 which will pass to stage 2 but offer 3 will not pass to stage two.

Looking at the results in Table 6, the FLC gives more accurate results than the traditional approach. For example, look at offer 3, although it has the lowest score in both evaluation methods, it has a very low score using the FLC approach. This happened because the FLC is based on rules that uses expert knowledge. The offer that has low level in both Technical Qualification (TEC-QUL)

Table 5. Tender #1 evaluation, comparison between the current approach and new proposed fuzzy approach using different defuzzification methods

Website Development Tender: Tender #1										
#	TEC-QUL	COM-EXP	SIM-DES	PM	SUP	Non-Fuzzy Current Technical Evaluation Value	FLC - Crisp Value Centroid	FLC - Crisp Value Bisector	FLC - Crisp Value MOM	FLC - Crisp Value SOM
1	29	20	30	10	10	99	94.7	95	96	96
2	30	10	18	5	10	73	70	70	70	65
3	5	10	30	10	7	62	6.95	6	3	0
4	28	20	30	10	7	95	94.3	94	95	92
5	27	14	18	5	8	72	74.9	74	70	60

Table 6. Tender #2 evaluation, compare between current approach and fuzzy approach using different defuzzification methods

Website Development Tender: Tender #2										
#	TEC-QUL	COM-EXP	SIM-DES	PM	SUP	Non-Fuzzy Current Technical Evaluation Value	FIS - Crisp Value Centroid	FIS - Crisp Value Bisector	FIS - Crisp Value MOM	FIS - Crisp Value SOM
1	27	20	30	10	10	97	94.6	95	95.5	95
2	22	10	18	5	10	65	50.9	55	70	60
3	24	10	30	10	7	81	50	50	50	50
4	8	20	24	10	7	69	7.67	7	5	0
5	13	14	18	5	8	58	37	37	30.5	21
6	28	16	28	10	10	92	94.5	95	95	93

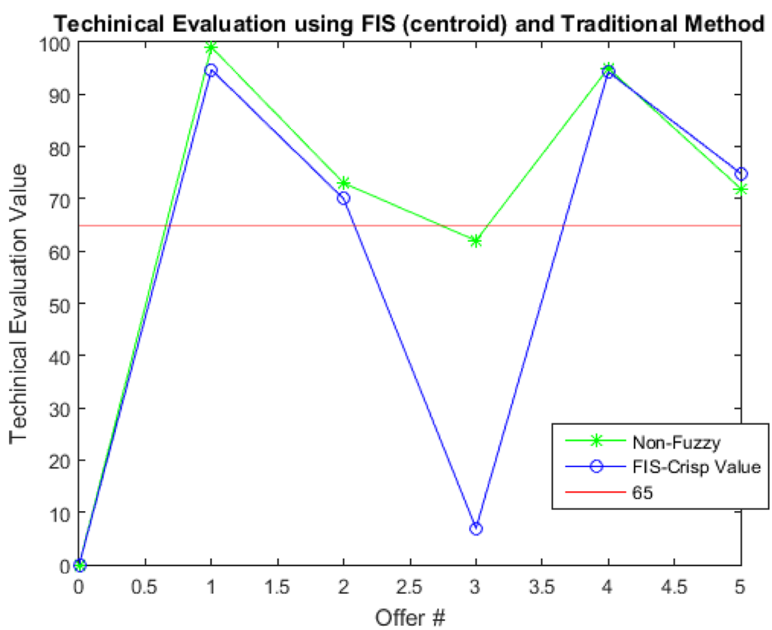
and Company Experience (COM_EXP) should be excluded directly from the competition regardless of other factors. That is because these two factors, according to expert opinion, represent the actual quality of the technical proposal.

Looking at offers 1 and 4, the score for both based on the equation differ by 4 points, but according to FLC score differ only by 0.4, that is because the two main factors TEC-QUL and COM_EXP are almost the same.

Figure 10 shows the comparison plot between the non-fuzzy (current technical evaluation value) and the new proposed FLC (FIS) (using Centroid to generate the crisp value) for tender 1.

Table 6 represent the result of the first stage evaluation for tender #2. According to the evaluation rules, only the offers that have scores over 65 will pass to stage two. As shown from the table according

Figure 10. Tender 1, comparison between non-fuzzy and FLC (FIS) with centroid crisp value



to the traditional evaluation offers 1, 2, 3, 4 and 6 will pass to stage 2, but according to fuzzy evaluation only offers 1 and 6 will pass to stage two.

The results in Table 7 shows that according to expert opinion, the companies that have high technical skills and high experience are desired to be part of the competition. But the other are not. So this will guide the Jordanian ministries to get the most quality products.

Figure 11 shows the plot of the comparison results between the non-fuzzy current technical evaluation value and FIS with crisp value (using Centroid) for tender 2.

Table 7. Tender #3 evaluation, compare between current approach and fuzzy approach using different defuzzification methods

Website Development Tender: Tender #3										
#	TEC-QUL	COM-EXP	SIM-DES	PM	SUP	Non-Fuzzy Current Technical Evaluation Value	FIS - Crisp Value Centroid	FIS - Crisp Value Bisector	FIS - Crisp Value MOM	FIS - Crisp Value SOM
1	12	16	24	10	10	72	24.7	25	30.5	16
2	22	15	30	5	10	82	65.4	64	95	92
3	30	10	30	10	7	87	50	50	50	50
4	30	20	26	10	7	93	94.4	94	95	92
5	27	12	26	5	8	78	72.7	72	70	62
6	18	16	22	8	5	69	53.5	52	40.5	16
7	30	14	15	5	6	70	74.9	74	70	60
8	28	16	22	10	10	86	94.4	94	95	92

Figure 11. Tender 2, comparison between the non-fuzzy and the FIS with centroid crisp value

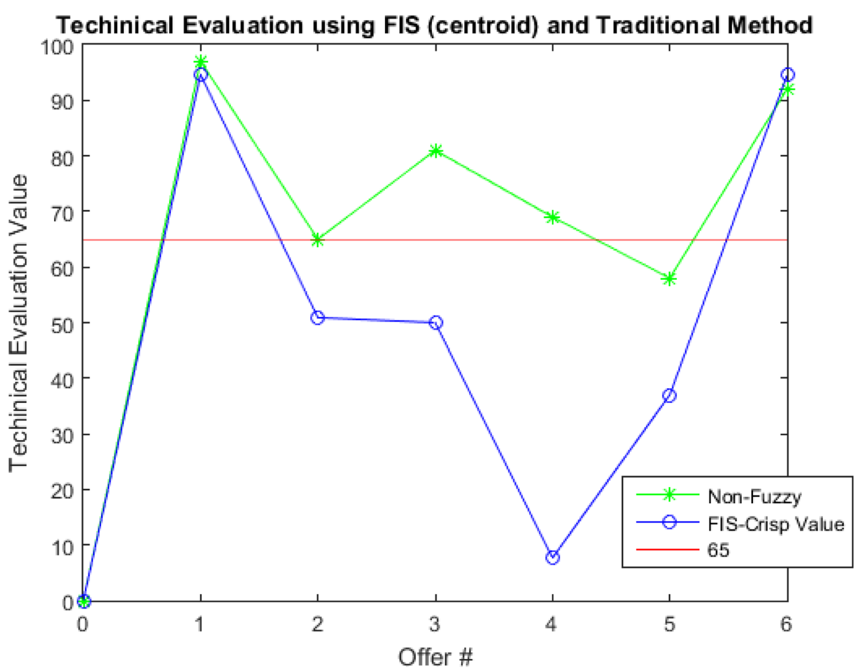


Table 7 represent the result of the first stages evaluation for tender #3. As shown in the table, according to traditional evaluation all offers 1 through 8 will pass to stage 2, but according fuzzy evaluation only offers 2, 4, 5, 7, and 8 will pass to stage two. That is also because according to expert opinion, the companies that have high technical skills and high experience are desired to be in the competition. But the others are not.

Figure 12 shows the plot of the comparison results between the non-fuzzy current technical evaluation value and the FIS with crisp value (using Centroid) for tender 3.

Table 8 shows the comparison result between the first stages of evaluation for tender #4. As shown in the table according to the traditional evaluation the offers 1, 3 and 4 will pass to stage 2, but according the fuzzy evaluation only offers 1, and 4 will pass to stage two. That is also because according to expert opinion, the companies that have high technical skills and high experience are desired to be in the competition. But the others are not.

Figure 12. Tender 3, comparison between non-fuzzy and the FIS with centroid crisp value

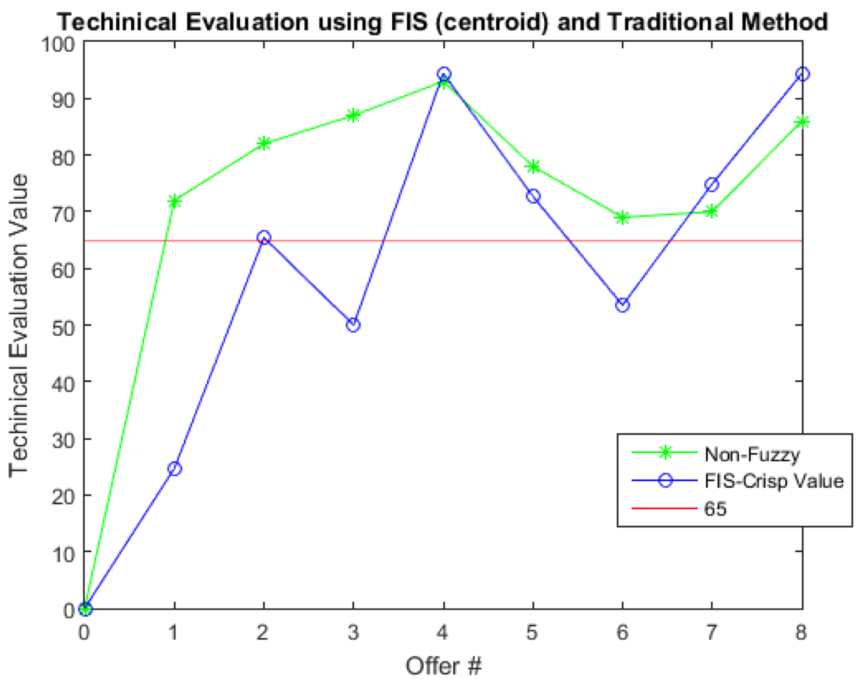


Table 8. Tender #4 evaluation, comparison between the current approach and the fuzzy approach using different defuzzification methods

Website Development Tender: Tender #4										
#	TEC-QUL	COM-EXP	SIM-DES	PM	SUP	Non-Fuzzy Current Technical Evaluation Value	FIS - Crisp Value Centroid	FIS - Crisp Value Bisector	FIS - Crisp Value MOM	FIS - Crisp Value SOM
1	27	15	30	5	10	87	76.6	76	95	92
2	22	10	18	5	8	63	50.9	55	70	60
3	21	10	20	8	8	67	44.9	39	30.5	21
4	23	20	30	10	10	93	94.5	95	95	93

Figure 13 shows the plot of the comparison results of the non-fuzzy current technical evaluation value and the FIS with crisp value (using Centroid) for tender 4.

Table 9 represent the comparison result of the first stages of evaluation for tender #5. As shown in Table 7 according to the traditional evaluation offers 1, 2, 4 and 5 will pass to stage 2, but according the fuzzy evaluation the offers 2, 4 and 5 will pass to stage two. That is also because according to expert opinion, the companies that have high technical skills and high experience are desired to be in the competition. But the others are not.

Figure 14 shows the plot of the comparison results between the non-fuzzy current technical evaluation value and the FIS with crisp value (using Centroid) for tender 5.

Figure 13. Tender 4, comparison between the non-fuzzy and the FIS with centroid crisp value

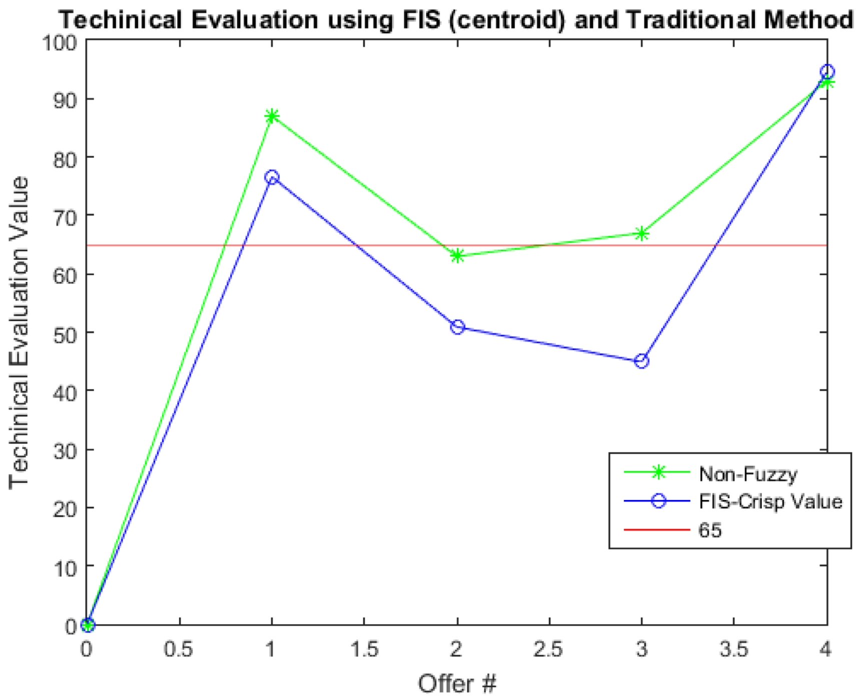


Table 9. Tender #3 evaluation, comparison between the current approach and the fuzzy approach using different defuzzification methods

Website Development Tender: Tender #5										
#	TEC-QUL	COM-EXP	SIM-DES	PM	SUP	Non-Fuzzy Current Technical Evaluation Value	FIS - Crisp Value Centroid	FIS - Crisp Value Bisector	FIS - Crisp Value MOM	FIS - Crisp Value SOM
1	12	10	30	8	7	67	8.78	9	8	0
2	30	10	18	5	10	73	70	70	70	65
3	5	10	30	10	7	62	6.95	6	3	0
4	28	20	30	10	7	95	94.4	94	95	92
5	27	14	18	5	8	72	74.9	74	70	60

Figure 14. Tender 5, comparison between the non-fuzzy and the FIS with centroid crisp value

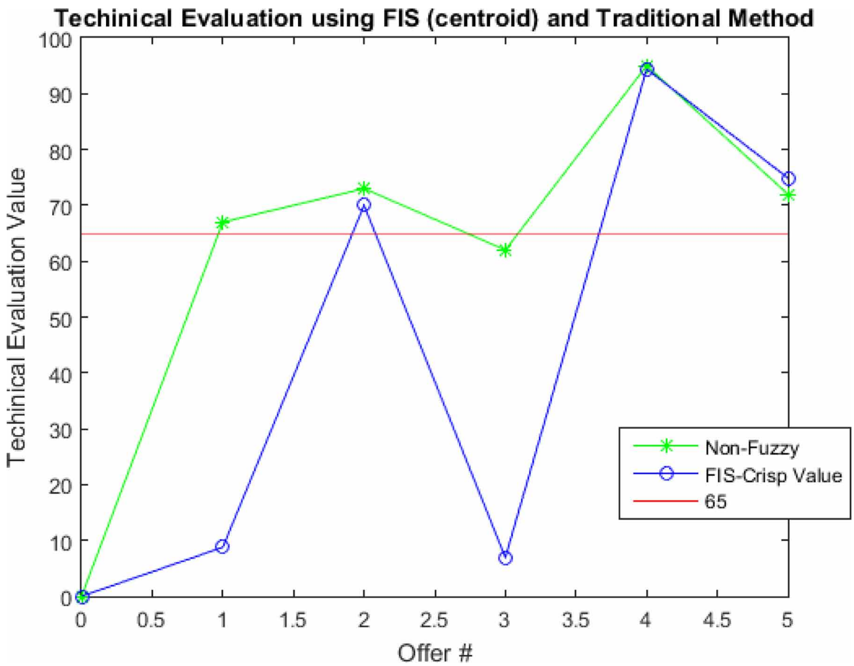


Table 10 shows the summary evaluation for the five tenders.

Looking at tender 2 in Table 11, the technical evaluation based on the current method has five offers which have passed to the second stage, but the Fuzzy method has passed only two offers. Referring to Table 5, the three offers that are excluded based on the fuzzy method have low scores in either technical qualification or company experience or in both of them. So, these offers should be excluded and should not have passed to the next stage, because according to expert opinion, the companies that are not qualified should not participated in the competition regardless of other factors. At the end of website development these two factors have the most important impact on the result of the delivered project.

Tender 3 also has the same issue as tender 2. Based on the current method all offers will pass, but based on the new fuzzy method only five offers will be passed to the next stage.

4.2. Testing Technical Evaluation FIS Module Based on Fabricated Data

Table 11 shows a fabricated data that is used to test the module. It also includes the results from using the traditional equation and the new FLC (FIS).

Table 10. Summarized result for tenders' technical evaluation

Tender #	Number of Offers	Current Method		Fuzzy Method	
		PASS	FAIL	PASS	FAIL
1	5	4	1	4	1
2	6	5	1	2	4
3	8	8	0	5	3
4	4	3	1	2	2
5	5	4	1	4	1

Table 11. Website development tender: Fabric data for testing

Website Development Tender: Fabric Data for Testing							
#	TEC-QUL	COM-EXP	SIM-DES	PM	SUP	Non-Fuzzy Current Technical Evaluation Value	FIS - Crisp Value Centroid
1	0	20	30	10	10	70	6.33
2	30	0	30	10	10	80	50
3	30	20	0	10	10	70	50
4	30	20	30	0	10	90	50
5	30	20	30	10	0	90	50

Table 11 shows that offer 1 has zero score for the input TEC-QUL and according to the new proposed FLC this offer will not pass to the next stage. Offer 1 has a score of 70 according to the traditional equation which wrongly result the offer to pass to the next stage. Although the TEC-QUL has the main effect on the evaluation result, but the remaining factors have the ability to reduce the FIS crisp score to 50 for the offers 2, 3, 4 and 5 which according to the 65 score requirement will cause them not to pass to the next stage.

5. CONCLUSION AND FUTURE WORK

Developing a new website for ministries and government institution is one of common tenders issued by the various ministries and government institutions all over the world. Results have shown that the new proposed FLC/FIS for evaluating tenders for website development at Jordanian ministries and government agencies has a better performance over the use of the traditional method. The new proposed method is a dynamic way of evaluating tenders that uses the fuzzy if-then rules and that has the ability to model ambiguity through defining linguistic values for the variables that are used for evaluating the tenders. The evaluation based on the new fuzzy method will allow the qualified companies to pass to the next stage of the competition. The evaluation based on the currently traditional method will pass offers by companies who are qualified and unqualified which will have bad impact on the final results of website development. The currently used method uses a static equation with fixed weights to evaluate tenders.

Tender evaluation has many factors that are unclear and ambiguous. The expert in designing this model focused on two factors; Technical Qualification (TEC-QUL) and Company Experience (COM_EXP) as the main factors that affect the evaluation. Simulation have shown that the new proposed method is more efficient and accurate than the currently used method.

In the coming fewer months, the Ministry of Information & Communications Technology (MOICT) in Jordan, will publish standard rules for the design of website, that all ministries and government institutions would have to follow when evaluating the design of their websites. When this standard is published, the new proposed FLC system can then be used to evaluate the tender offers by the software companies. The FLC design evaluation will be very useful because there are many uncertainty factors that can affect the evaluation, for example: Look and Feel, Usability, Simplicity, Accessibility and others.

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