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Selection of domotic systems by AHP based rules weights calculation on models of fuzzy rules

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Abstract. Many methods exist for performing multi-criteria decision making; one of them is carrying out the decision making based on fuzzy logic. This method is useful when you have qualitative information that is difficult to handle by other methods that work with "crisp" values. This article presents a novel method using AHP (Analytic Hierarchy Process) to determine the weights of the rules that constitute the fuzzy inference model. The advantage provided by this new method is that the weights assigned to the rules are calculated using the AHP methodology, which appart from the values of the weights it gives us a value of the consistency of these weights. We have developed a fuzzy model to calculate weights by AHP and two cases were analyzed for the choice of the appropriate technology for home automation system. The results have been compared with a fuzzy model generated for the same purpose in a previous work and they are similar.

Key words

Domotic systems, MADM (Multi Attribute Decision Making), Fuzzy Logic, Model rule-based, AHP (Analitic Hierarchy Process)

1. Introduction

Madm (Multi Attribute Decision Making) is the extended branch for decision making. It is the branch of operations research to solve problems dealing with decision making based on several criteria. The typical problem is the selection of one among several alternatives taking into account a number of attributes or criteria. Such problems do not work on an infinite number of solutions but on a set of predefined alternatives beforehand. Traditional methods combine the information into a decision matrix along with additional information in order to establish a ranking of alternatives. To deal with qualitative or imprecise information [Zadeh (1965)] suggests the use of fuzzy theory as a tool for modeling complex systems controlled by humans and that can hardly be modeled accurately by other methods. Fuzzy logic allows a computer to model the real world as a person does. It provides a vague and imprecise to deal with information that often acts as an input in our reasoning. There are many methods for performing multi decision making, [Hwang and Yoon (1981)] collected several, among the most important we highlight Dominance, Maximin, maximax, conjunctive (satisficing), disjunctive, lexicographic, Elimination by Aspects, Linear Assignment Method, Additive Weighting, Weighted Product, Nontraditional Capital Investment Criteria, TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), Distance from Target, and Analytic Hierarchy Process (AHP), Methods outranking (ELECTRE, PROMETHEE, Orestes), Multiple Attribute Utility Models, Analytic Network Process, Data Envelopment Analysis, Multi-Attribute Fuzzy Integrals, Multi Attribute Decision Making Fuzzy Rule-Based Model (FMADMMRF).

2. Limitations of the existing methods

The method FMADMMRF proposed by [Mandic J.N. and Mamdani h.e. (1984)] takes the information from each of the attributes to take into account, the process undergoes a fuzzyfication and then applies a set of rules based on knowledge of one or more experts. Each of these rules is assigned a weight. Once applied all rules applicable to the sum of the results of the rules and finally defuzzyfication process. One limitation that has the method is the calculation of the weights of the rules, these are usually assigned by direct allocation, often directly assigned weight 1 and associated software then applies this weight to all rules equally without give more or less importance to some or other. This can cause the problem that rules are not relevant to determine the alternative of choice in our decision-making system causing the chosen alternative is not the most appropriate.

3. New method proposal

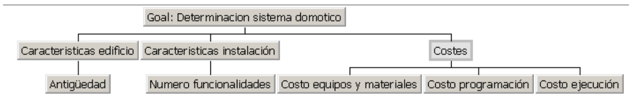
The AHP method is a method widely used as a method of making decisions, there is even software (Expert Choice) that uses the above method as the basis for the decision making process. In AHP first choose the criteria to be used for the election and then will compare the relative importance of each pair of criteria. In this comparison using the Saaty scale, a scale that assesses the importance of one criterion over another between 1 and 9. Once all possible comparisons of criteria, we obtain the matrix of criteria and from it the vector of priorities, which in our case we will use as a vector of weights of the rules.

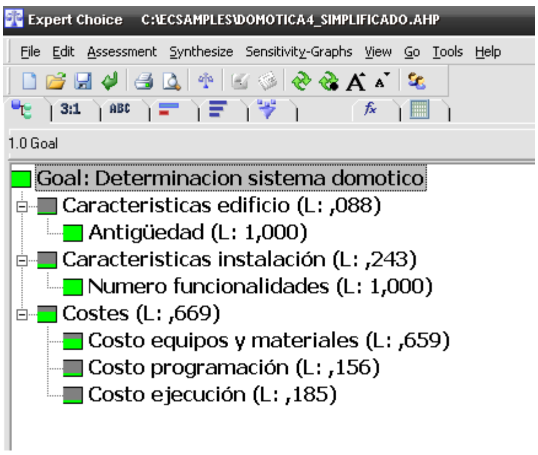
4. Methodology

The methodology used was the following, we use AHP to determine the weights of the criteria, which in our case coincide with the rules. We created a model based on fuzzy logic rules which generate many rules and membership functions have our tickets. We define rules based on expert knowledge. We assign weight to each rule obtained by the AHP. Once the model was subjected to a couple of examples of input and check the result with the rules-based model [Saenz and Jimenez (2008)] and [Sáenz Jiménez And And Perez (2008)].

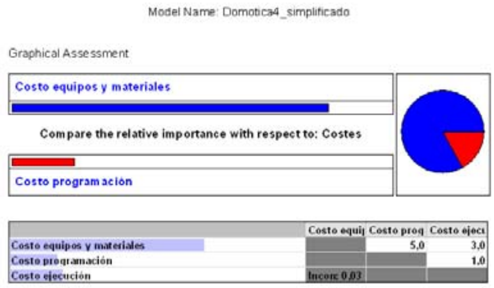
5. Model evaluation

The proposed model has been applied in a problem of technology selection of a home automation system. It takes into account the following attributes or criteria, building characteristics, characteristics of the installation and costs. Each in turn has a number of sub-criteria, as the program displays the Expert Choice.

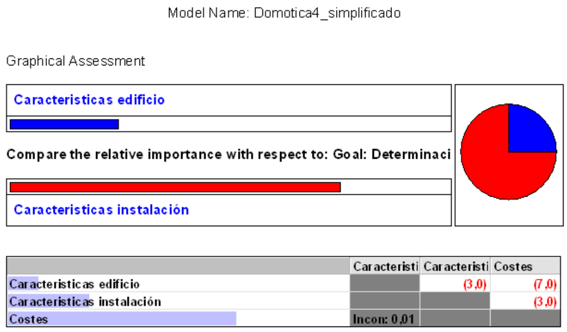




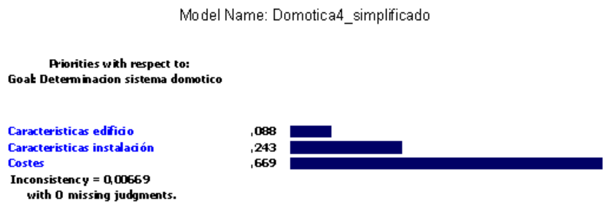
We perform pairwise comparison of subcriteria for the criterion "Costs" performing the evaluation according to the Saaty scale.



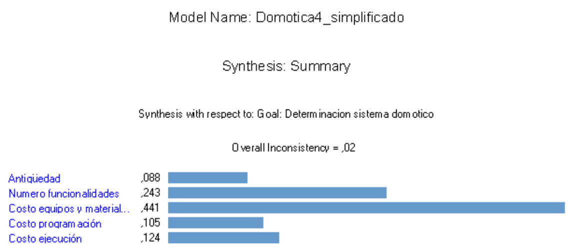
Then we perform the pairwise comparison of criteria using the same scale as in the previous case.



From this comparison we obtain the matrix of criteria, from which we obtain by applying AHP weights of the criteria, and the results which are shown below.

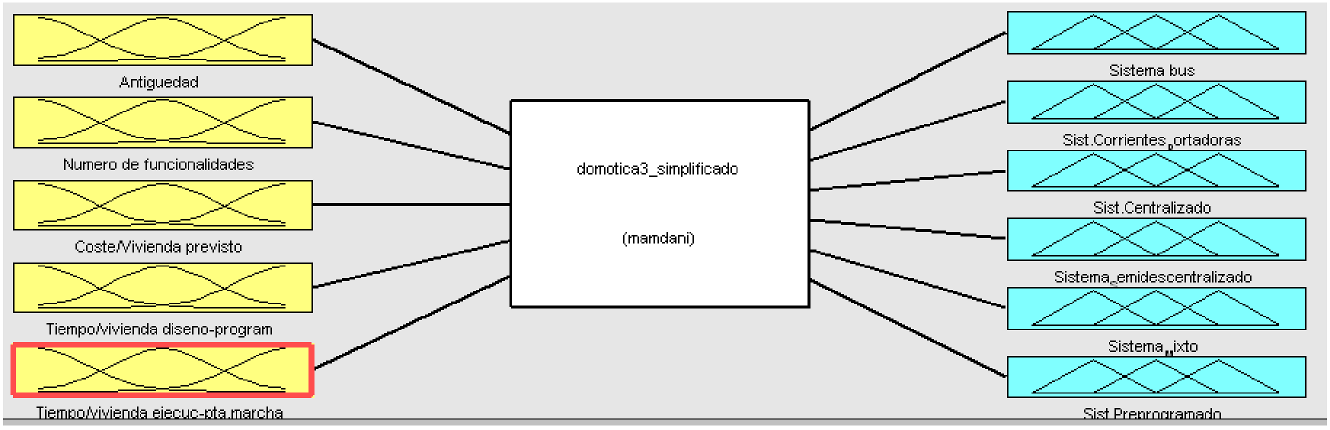


In the case of costs can be broken weight among the 3 sub final weights obtained the following:



The inconsistencies of the criteria is 2%, well below the 10% recommended as suitable Saaty.

We generate the rule-based fuzzy model. In our case we will have 5 entries defined by 14 membership functions of Gaussian type, defined by 3 to 6 outputs membership functions and triangle type inference system based on 14 rules. To develop the model it has been used MATLAB and the Fuzzy Logic Toolbox.



The MATLAB model is defined by a file "*. fis", which defines the inputs and outputs, and their membership functions. At the end of this file it shows the 14 rules with weights calculated by AHP.

[System]
Name='domotica3_simplificado'
Type='mamdani'
Version=2.0
NumInputs=5
NumOutputs=6
NumRules=14
AndMethod='min'
OrMethod='max'
ImpMethod='min'
AggMethod='max'
DefuzzMethod='centroid'

[Input1]
Name='Antiguedad'
Range=[0 100]
NumMFs=3
MF1='pequena':'gaussmf',[20 0]
MF2='media':'gaussmf',[20 20]
MF3='alta':'gaussmf',[50 100]

[Input2]
Name='Numero de funcionalidades'
Range=[1 12]
NumMFs=2
MF1='basico':'gaussmf',[2 1]
MF2='normal':'gaussmf',[2 12]

[Input3]
Name='Coste/Vivienda previsto'
Range=[0 6000]
NumMFs=3
MF1='bajo':'gaussmf',[1548.10333366975 58.2]
MF2='normal':'gaussmf',[1000 3000]
MF3='alto':'gaussmf',[1000 6000]

[Input4]
Name='Tiempo/vivienda diseno-program'
Range=[0 20]
NumMFs=3
MF1='bajo':'gaussmf',[4 1]
MF2='normal':'gaussmf',[4 10]
MF3='alto':'gaussmf',[4 20]

[Input5]
Name='Tiempo/vivienda ejecuc-pta.marcha'
Range=[0 100]
NumMFs=3
MF1='bajo':'gaussmf',[20 10]
MF2='normal':'gaussmf',[20 50]
MF3='alto':'gaussmf',[20 100]

[Output1]
Name='Sistema bus'
Range=[0 1]
NumMFs=3
MF1='no aconsejado':'trimf',[-0.4 0 0.4]
MF2='aconsejado':'trimf',[0.1 0.5 0.9]
MF3='muy aconsejado':'trimf',[0.6 1 1.4]

[Output2]
Name='Sist.Corrientes_Portadoras'
Range=[0 1]
NumMFs=3
MF1='no aconsejado':'trimf',[-0.4 0 0.4]
MF2='aconsejado':'trimf',[0.1 0.5 0.9]
MF3='muy aconsejado':'trimf',[0.6 1 1.4]

[Output3]
Name='Sist.Centralizado'
Range=[0 1]
NumMFs=3
MF1='no aconsejado':'trimf',[-0.4 0 0.4]
MF2='aconsejado':'trimf',[0.1 0.5 0.9]
MF3='muy aconsejado':'trimf',[0.6 1 1.4]

[Output4]
Name='Sistema_Semidescentralizado'
Range=[0 1]
NumMFs=3
MF1='no aconsejado':'trimf',[-0.4 0 0.4]
MF2='aconsejado':'trimf',[0.1 0.5 0.9]
MF3='muy aconsejado':'trimf',[0.6 1 1.4]

[Output5]
Name='Sistema_Mixto'
Range=[0 1]
NumMFs=3
MF1='no aconsejado':'trimf',[-0.4 0 0.4]
MF2='aconsejado':'trimf',[0.1 0.5 0.9]
MF3='muy aconsejado':'trimf',[0.6 1 1.4]

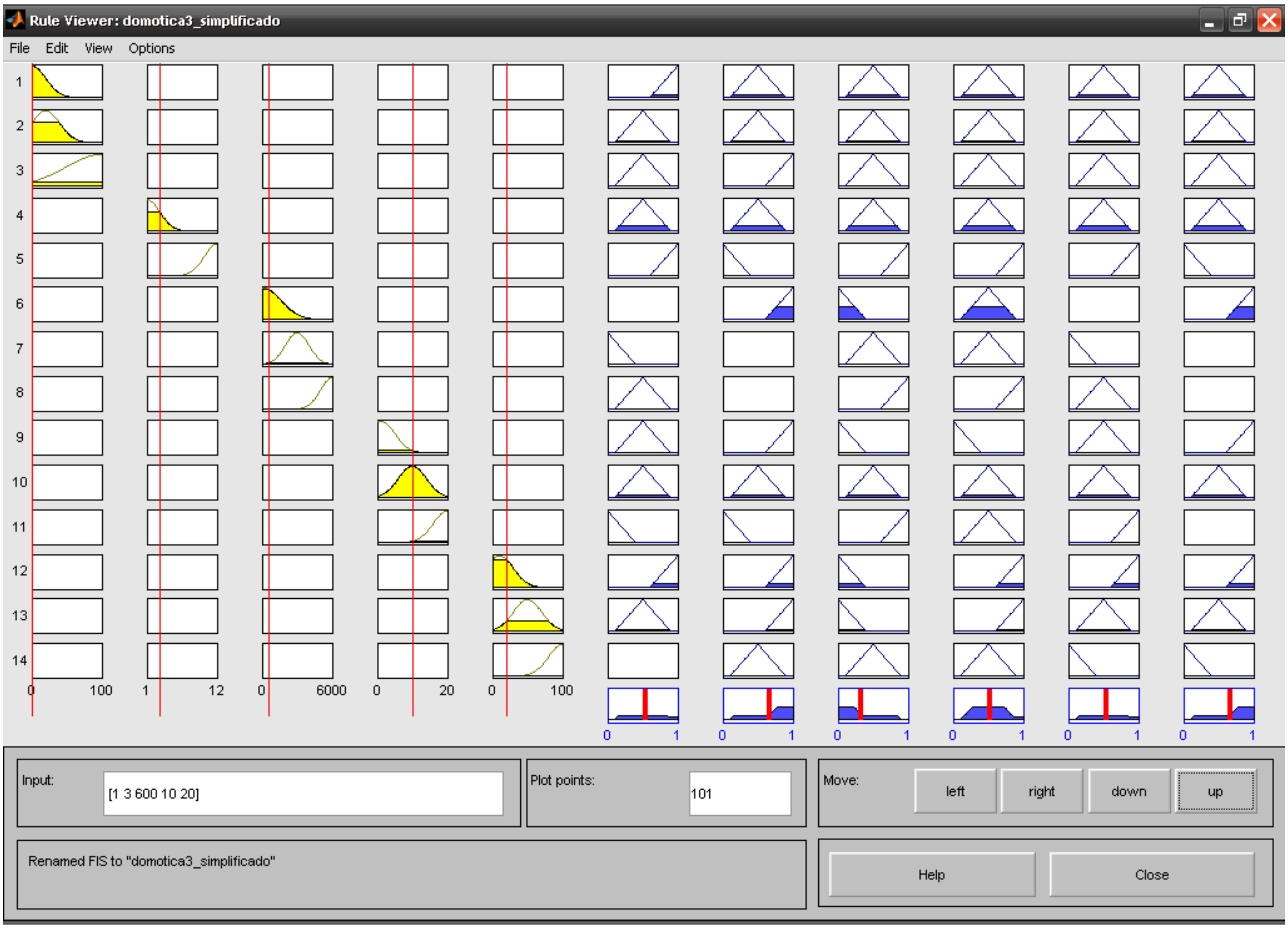
[Output6]
Name='Sist.Preprogramado'
Range=[0 1]
NumMFs=3
MF1='no aconsejado':'trimf',[-0.4 0 0.4]
MF2='aconsejado':'trimf',[0.1 0.5 0.9]
MF3='muy aconsejado':'trimf',[0.6 1 1.4]

[Rules]
1 0 0 0 0, 3 2 2 2 2 2 (0.088) : 1
2 0 0 0 0, 2 2 2 2 2 2 (0.088) : 1
3 0 0 0 0, 2 3 2 2 2 2 (0.088) : 1
0 1 0 0 0, 2 2 2 2 2 2 (0.243) : 1
0 2 0 0 0, 3 1 3 3 3 1 (0.243) : 1
0 0 1 0 0, 0 3 1 2 0 3 (0.441) : 1
0 0 2 0 0, 1 0 2 2 1 0 (0.441) : 1
0 0 3 0 0, 2 0 3 3 2 0 (0.441) : 1
0 0 0 1 0, 2 3 1 1 2 3 (0.105) : 1
0 0 0 2 0, 2 2 2 2 2 2 (0.105) : 1
0 0 0 3 0, 1 1 3 2 3 0 (0.105) : 1
0 0 0 0 1, 3 3 1 3 3 3 (0.124) : 1
0 0 0 0 2, 2 3 1 3 2 2 (0.124) : 1
0 0 0 0 3, 0 2 2 2 1 1 (0.124) : 1

6. Results

A. CASE 1- FAMILY HOUSE

We conducted two tests to evaluate the performance of the model. The following figure shows how the model evaluates the case of a house. On the left fuzzyficacition of entries. On the right the result of application of the rules, eventually adding all the results and applying the method defuzzyfication Centroid finally gives us a result that serves as the ranking of alternatives.



Input data

number of housings	1
building age	3
number of functionalities	5
estimated cost per housing	6000
design and planning time	10
implementation and start-up time	20

The obtained results are:

bus system	0,520354659316663
carrier current system	0,564670862875505
centralized system	0,667694682589795
decentralized system	*0,710613249777613*
mixed system	0,520354659316663
preprogrammable system	0,567117443325232

The system determines the most appropriate technology for single-family housing would be a decentralized system.

B. CASE 2-BUILDING

Input data

number of housings	35
building age	0
number of functionalities	5
estimated cost per housing	4000
design and planning time	6
implementation and start-up time	20

The obtained results are:

bus system	0,382271002265931
carrier current	*0,584836381641615*
centralized system	0,485420370732700
decentralized	0,517893547192486
mixed system	0,387034742195108
preprogrammable	0,484836381641615

In this case the chosen alternative is the current carriers.

The results of both cases coincide with those obtained by [Saenz and Jimenez (2008)].

7. Conclusions

The proposed method is a hybrid between traditional AHP and Fuzzy rule-based model that allows us to easily calculate the weights of the model rules. It also provides a value on the consistency of the weights that allows us to measure its adequacy. The method has been evaluated in the selection of a home automation system and the results have been compared with those obtained by other methods and the result is similar.

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