

SOFTWARE FOR INTERCRITERIA ANALYSIS: WORKING WITH THE RESULTS

Deyan Mavrov

Laboratory of Intelligent Systems, “Prof. Dr. Asen Zlatarov” University
Prof. Yakim Yakimov Blvd., 8010 Burgas, Bulgaria
e-mail: dg@mavrov.eu

Abstract: InterCriteria Analysis, a new approach for multi-criteria analysis, has been tested using a custom application program, developed to easily give the results from a table of input data. This paper describes how the program is to be used to process the results, visualize them, as well as what formats the program uses and certain other details required for the correct functioning of the software. Features added since the initial description of the program have been described as well.

Keywords: Intuitionistic Fuzzy InterCriteria Analysis Method, Intuitionistic fuzzy sets, Index matrix, Multicriteria decision making.

1 Introduction

InterCriteria Analysis (ICA), presented first in 2013 and described in [1], provides a new method to find the Intuitionistic Fuzzy degree of relationship between each pair from a set of criteria. In ICA, input comes in the form of an Index Matrix (IM) containing evaluations of objects by a set of criteria. From these evaluations, after applying the ICA algorithm, a new IM is produced, where all criteria from the set are evaluated against each other with Intuitionistic Fuzzy Pairs (IFP), which determine the degree of correspondence between them.

To help test the method against different input data sets, a C++ application was developed, which allows us to quickly perform InterCriteria analysis and further to visualize the results and apply some other operations on them [2]. The functionality of this application is described in more detail in this paper.

2 Calculating and exporting the results

As described in [2], the program takes input in the form of one or two tables stored in either the first sheet of an Excel workbook, or a tab-delimited text file.

In order for a table to be processed correctly by the program, it must have object names in the first row, and criterion names in the first column, with the first cell on line one left unused. If two tables are provided, they should be one below the other with an empty line in between, and object names should be provided only for the first table, as the criteria in table two must evaluate the same objects. If one table is provided, the criteria are compared with themselves. If two tables are provided, the criteria from the first table are compared with those from the second one.

	A	B	C	D	E	F	G	H
1		O1	O2	O3	O4	O5	O6	O7
2	C1	5,7	5,2	3,3	3,8	5	3,9	6,2
3	C2	5,9	5,6	2,8	4	5,2	4,1	6
4	C3	5,4	5,1	5,2	5,1	5,3	5,4	5,9
5	C4	6,3	6,5	5,5	5,9	6,4	6,1	6,4
6	C5	5,3	5,6	4,1	4,4	4,7	5	6
7	C6	5,4	5,2	4,1	4,1	4,9	4,7	5,4
8	C7	4,6	4,3	4,4	4,4	4,4	4,7	5,6
9								

1	O1	O2	O3	O4	O5	O6	O7	
2	C1	5,7	5,2	3,3	3,8	5	3,9	6,2
3	C2	5,9	5,6	2,8	4	5,2	4,1	6
4	C3	5,4	5,1	5,2	5,1	5,3	5,4	5,9
5	C4	6,3	6,5	5,5	5,9	6,4	6,1	6,4
6	C5	5,3	5,6	4,1	4,4	4,7	5	6
7	C6	5,4	5,2	4,1	4,1	4,9	4,7	5,4
8	C7	4,6	4,3	4,4	4,4	4,4	4,7	5,6
9								

Figure 1. Example input table as XLSX and a tab-delimited file (with Bulgarian formatting)

When an input file is selected, the program asks for certain options to be configured. These include the type of values, whether to expect one or two tables as input, and how to treat equalities between object values when performing the analysis. These settings, as well as the last directory where a file was opened, are remembered in an OS-specified location [3].

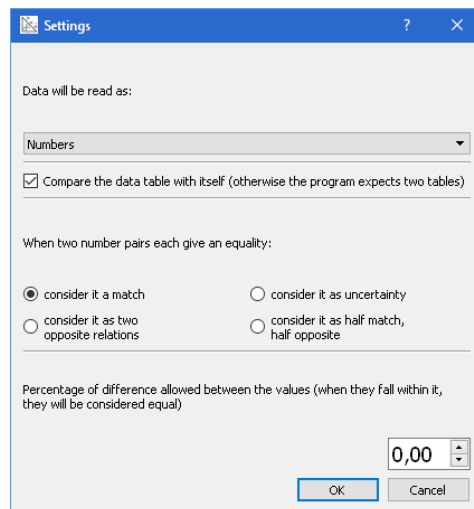


Figure 2. Settings window

Before any other functionality of the program can be used, one must analyze the input data to produce the matrix of Intuitionistic Fuzzy Pairs. For this purpose the application splits the work across the available processor cores, performs comparisons and calculations, and stores the results in memory. The results are displayed in the application's main window.

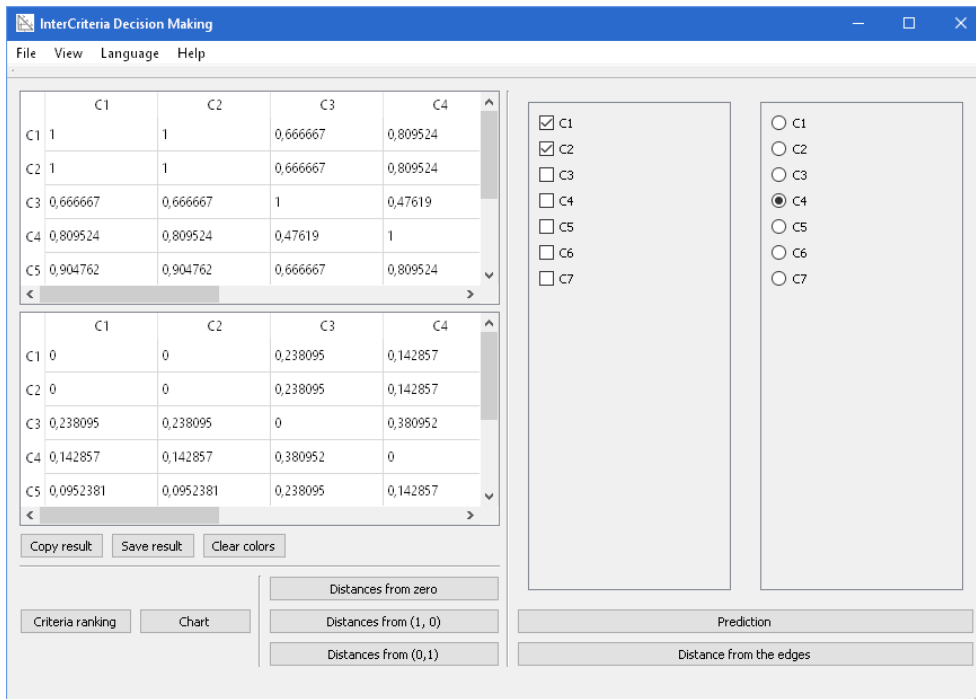


Figure 3. Main window with results from the above example input (Bulgarian formatting)

Since they consist of a matrix of pairs, for practical purposes the matrix is split into two matrices – one for the degrees of membership (μ), and the other for the degrees of non-membership (ν). That way they can be imported into spreadsheet software and explored further. For this purpose, the program offers two methods of work:

- Pressing the “Copy Result” button puts the two matrices in the system clipboard, from where they can be pasted into another application
- Pressing the “Save Result” button saves the two matrices in:
 - the second sheet of the input file, if it is a workbook, or
 - an output text document with tab-separated values, if the input file is a tab-delimited document.

In both cases, the result matrices are placed one below the other, with the membership matrix on top and the non-membership matrix below. The decimal point format of the numbers exported by the program depends on the region settings of the system.

	A	B	C	D	E	F	G	H
1	ρ	C1	C2	C3	C4	C5	C6	C7
2	C1	1	1	0,666667	0,809524	0,904762	0,904762	0,571429
3	C2	1	1	0,666667	0,809524	0,904762	0,904762	0,571429
4	C3	0,666667	0,666667	1	0,47619	0,666667	0,619048	0,761905
5	C4	0,809524	0,809524	0,47619	1	0,809524	0,714286	0,380952
6	C5	0,904762	0,904762	0,666667	0,809524	1	0,809524	0,571429
7	C6	0,904762	0,904762	0,619048	0,714286	0,809524	1	0,571429
8	C7	0,571429	0,571429	0,761905	0,380952	0,571429	0,571429	1
9								
10	σ	C1	C2	C3	C4	C5	C6	C7
11	C1	0	0	0,238095	0,142857	0,095238	0	0,285714
12	C2	0	0	0,238095	0,142857	0,095238	0	0,285714
13	C3	0,238095	0,238095	0	0,380952	0,238095	0,190476	0
14	C4	0,142857	0,142857	0,380952	0	0,142857	0,142857	0,428571
15	C5	0,095238	0,095238	0,238095	0,142857	0	0,095238	0,285714
16	C6	0	0	0,190476	0,142857	0,095238	0	0,285714
17	C7	0,285714	0,285714	0	0,428571	0,285714	0,285714	0

1	?	C1	C2	C3	C4	C5	C6	C7
2	C1	1	1	0,6666666666666663	0,8095238095238095	0,9047619047619047	0,9047619047619047	0,5714285714285714
3	C2	1	1	0,6666666666666663	0,8095238095238095	0,9047619047619047	0,9047619047619047	0,5714285714285714
4	C3	0,6666666666666663	0,6666666666666663	1	0,4761904761904762	0,6666666666666663	0,6190476190476190	0,7619047619047619
5	C4	0,8095238095238095	0,8095238095238095	0,4761904761904762	1	0,8095238095238095	0,7142857142857143	0,3809523809523809
6	C5	0,9047619047619047	0,9047619047619047	0,6666666666666663	0,8095238095238095	1	0,8095238095238095	0,5714285714285714
7	C6	0,9047619047619047	0,9047619047619047	0,6190476190476190	0,7142857142857143	0,8095238095238095	1	0,5714285714285714
8	C7	0,5714285714285714	0,5714285714285714	0,7619047619047619	0,3809523809523809	0,5714285714285714	0,5714285714285714	1
9								
10	?	C1	C2	C3	C4	C5	C6	C7
11	C1	0	0	0,23809523809523808	0,14285714285714285	0,09523809523809523	0	0,28571428571428571
12	C2	0	0	0,23809523809523808	0,14285714285714285	0,09523809523809523	0	0,28571428571428571
13	C3	0,23809523809523808	0,23809523809523808	0	0,38095238095238095	0,23809523809523808	0,19047619047619047	0
14	C4	0,14285714285714285	0,14285714285714285	0,38095238095238095	0	0,14285714285714285	0,14285714285714285	0,42857142857142857
15	C5	0,09523809523809523	0,09523809523809523	0,23809523809523808	0,14285714285714285	0	0,09523809523809523	0,28571428571428571
16	C6	0	0	0,19047619047619047	0,14285714285714285	0,09523809523809523	0	0,28571428571428571
17	C7	0,28571428571428571	0,28571428571428571	0	0,42857142857142857	0,28571428571428571	0,28571428571428571	0

Figure 4. Output as XLSX and tab-delimited values

Once the results are calculated and displayed, they are kept in memory, along with the input values. They can be used for the operations described later in this document.

3 Prediction

One of the initial ideas for ICA has been to use it as the basis for value prediction. The basic principle is as follows: Let us have two or more criteria (called *C-criteria* henceforth) that have been found to be in consonance with another criterion (*D-criterion*) after performing InterCriteria Analysis on them. If we enter a new object, which has been evaluated against the C-criteria, but not against the D-criterion, we can try to predict what value it could have, based on the relationship between each of the C-criteria and the D-criterion. To achieve this, two algorithms have been devised [1].

The application program described here provides a module for applying the two prediction algorithms. The criteria selection box is located on the right side of the results.

Figure 5. Selection of C-criteria (left column) and a D-criterion (right column)

First, the user needs to select a D-criterion from the right column. Then, based upon the results and the information provided by the application's other tools, the user has to choose one or more C-criteria from the left column such that they are in consonance with the C-criterion. Then the user needs to press the Prediction button to open the Value Prediction dialog.

There, the user has the option to either provide C-criteria values for a new object or the test the methods with all available input data, by ignoring each object's D-criterion value and using the C-criteria values to predict it as if it were not present. Then, the results calculated using both methods are printed out along with the original values from the D-criterion. This way the results from the prediction can be compared with the real values, so the algorithms can be improved. New algorithms can be added as well.

	1	2	3	4	5
1 D values	6.3	6.5	5.5	5.9	6.4
2					
3 y_min1	6.424999999999999	6.342857142857143		6	6.39
4 y_max1	6.450000000000000	6.371428571428571		6.053846153846153	6.43
5 y_avg1	6.4375	6.357142857142857		6.026923076923076	6.41
6					
7 y2	6.462500000000000	6.342857142857142		6.026923076923076	6.41
8					

Figure 6. Prediction window, testing the results of the two algorithms

If the user chooses to manually enter the data for a new object, one of the buttons for the prediction methods needs to be pressed. The resulting prediction will appear in a message box.

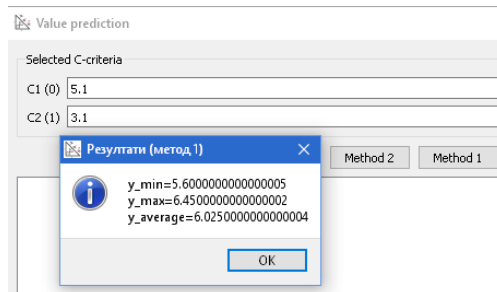


Figure 7. Prediction for a single object with values for the C-criteria

4 Graphical presentation of the results

Since the results are Intuitionistic Fuzzy Pairs (IFPs), the clearest way to visualize them is through the IF triangle [5]. To do this, the program provides a module that draws each IFP as a gray point inside a resizable triangle [4]. The triangle view opens when the Chart button is pressed.

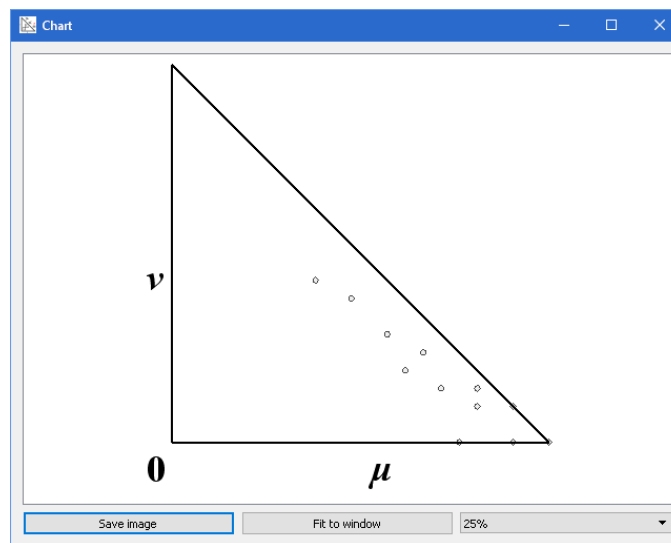


Figure 8. The IF triangle view

If it is needed to see which criteria pairs correspond to a set of points, one could drag a rectangle around them, which will open a window with the pairs found in the selected area.

Additionally, the program provides an option to highlight points in the triangle view. To do this, the user must double-click on a cell in one of the result tables, and then pick a color in the color selection window that appears. The cell's background color changes to the selected color. Since both the membership and non-membership are referring to the same pair of criteria, the corresponding cell in the other table also has its background color changed.

Then, when the user presses the Chart button, their points in the chart will be in their respective colors.

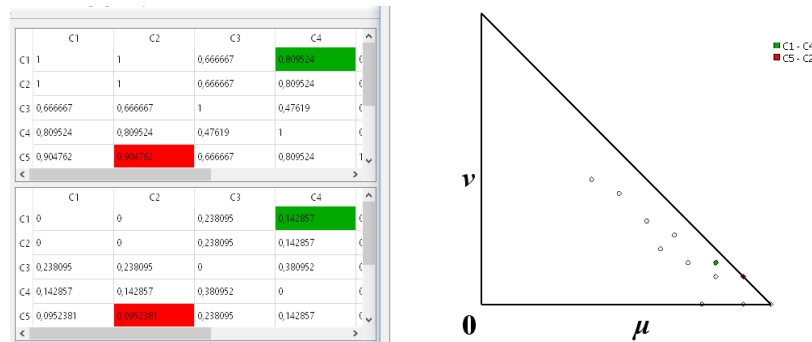


Figure 9. Highlighted criteria pairs

5 Ranking

The criteria pairs can be ranked in using the method described in [6]. The IF triangle is divided with a rectangular grid, which is based on the position of the points representing the criteria pairs. This method (using the diagonal strategy) has been implemented in the application as a function, which is activated when the user presses the Criteria Ranking button. The result appears as a list of criteria pairs with ranks, where some pairs might fall under the same rank, which is consistent with the way the traversing method operates.

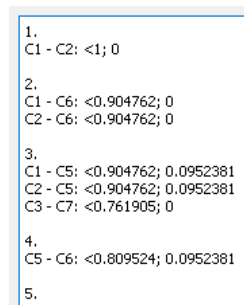


Figure 10. Criteria ranking

6 Conclusion

The InterCriteria Analysis application, initially written to implement only the main algorithm, has been sequentially updated with new features, and while simple in nature, it has proven itself as easy to use and useful for initial analysis and visualization of the results. Improvement on the prediction algorithms will continue as well, with the application as one of the tools to be used in the process. Providing a customized application has helped us to apply ICA in many areas, and it will continue to be updated when needed.

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