Software for Intercriteria Analysis: Implementation of a Normalization Step before Data Processing

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Today's Agenda

1. Software for Intercriteria Analysis
2. ICrA results with and without normalization step– ICrA by countries and years
3. ICrA results visualization – display data points with colors
4. Conclusion

Introduction

Intercriteria analysis (ICrA) is a tool that assesses the degree of association between investigated criteria of multivariate objects

It was created at Institute of Biophysics and Biomedical Engineering – Bulgarian Academy of Sciences (IBPhBME-BAS) in 2014

The formula

$$X_{new} = \frac{X - X_{min}}{X_{max} - X_{min}}$$

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```
std::vector< std::vector<double> > data1_transposed(data1[0].size(),std::vector<double>(data1.size()));

if(flip)
    for(size_t j=0; j<data1.size(); j++){
        for(size_t i=0; i<data1[j].size(); i++){
            data1_transposed[i][j] = data1[j][i];
        }
    }
else
    data1_transposed=data1;

for(size_t x=0; x<data1_transposed.size(); x++){
    std::vector<double>& row=data1_transposed[x];
    double min = *std::min_element(row.begin(), row.end());
    double max = *std::max_element(row.begin(), row.end());

    for(size_t z=0; z<row.size(); z++){
        if(flip) data1[z][x] = (data1_transposed[x][z]-min)/(max-min);
        else data1[x][z] = (data1_transposed[x][z]-min)/(max-min);
    }
}
```

Fig.1. The C++ code called by pressing the normalization button

An example input data worksheet

	A	B	C	D	E	F	G	H	I	J	K
1		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
2	Belgium	344	10,23	11,25	50	14,02	15,9	17,21	77	14,78	17,08
3	Bulgaria	245	1,05	1,96	70	1,78	2,42	1,45	234	1,51	1,7
4	Czechia	2535	5,59	3,77	120	6,7	7,5	7,97	425	7,62	16,43
5	Denmark	646	25,61	22,61	202	20,65	21,67	25,51	34	28,3	31,48
6	Germany	3636	28,25	32,9	124	35,35	30,44	30,82	365	30,86	35,75
7	Estonia	3646	4,38	4,8	244	8,28	17,45	15,3	2463	16,11	19,2

Fig.2 The input data

Software interface page

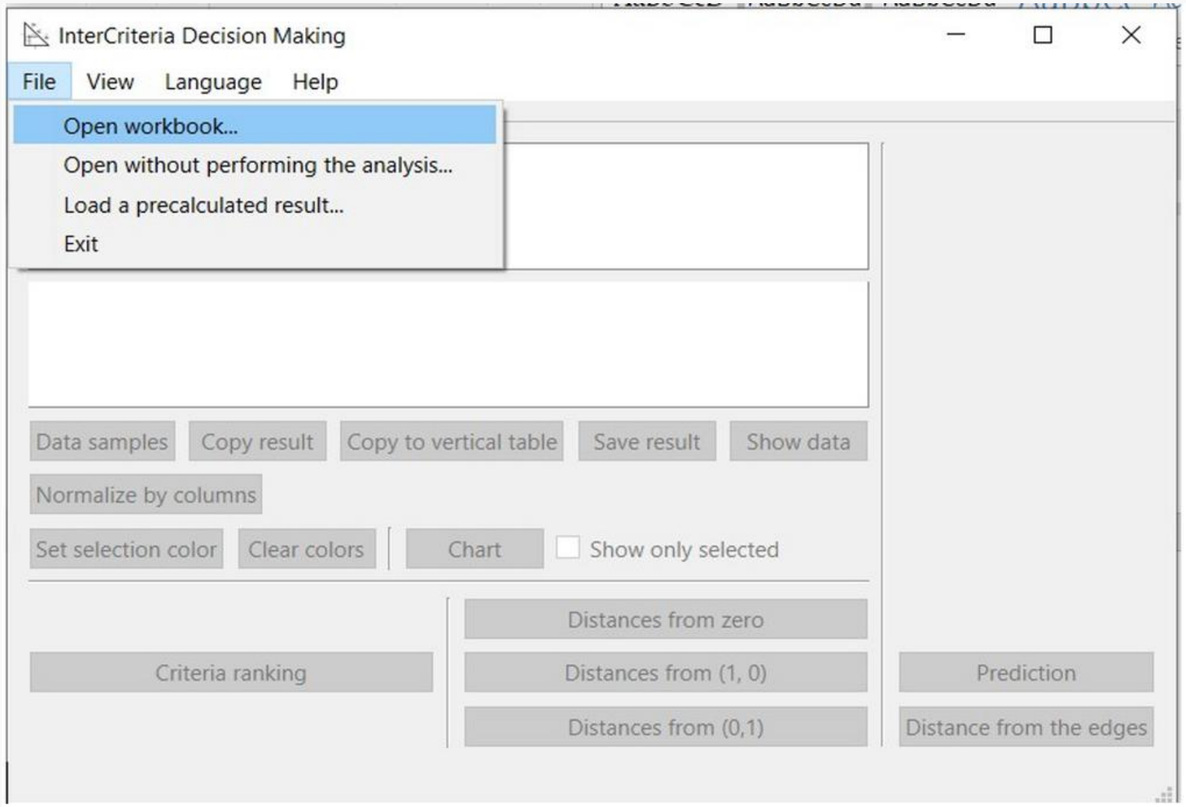

Fig.3 Open a workbook

The input file contains a series of numerical evaluations of a set of objects according to a set of criteria. The software performs ICrA on the input data and generates intuitionistic fuzzy pairs that represent the calculated degrees of membership and non-membership between each pair of criteria.

Data input

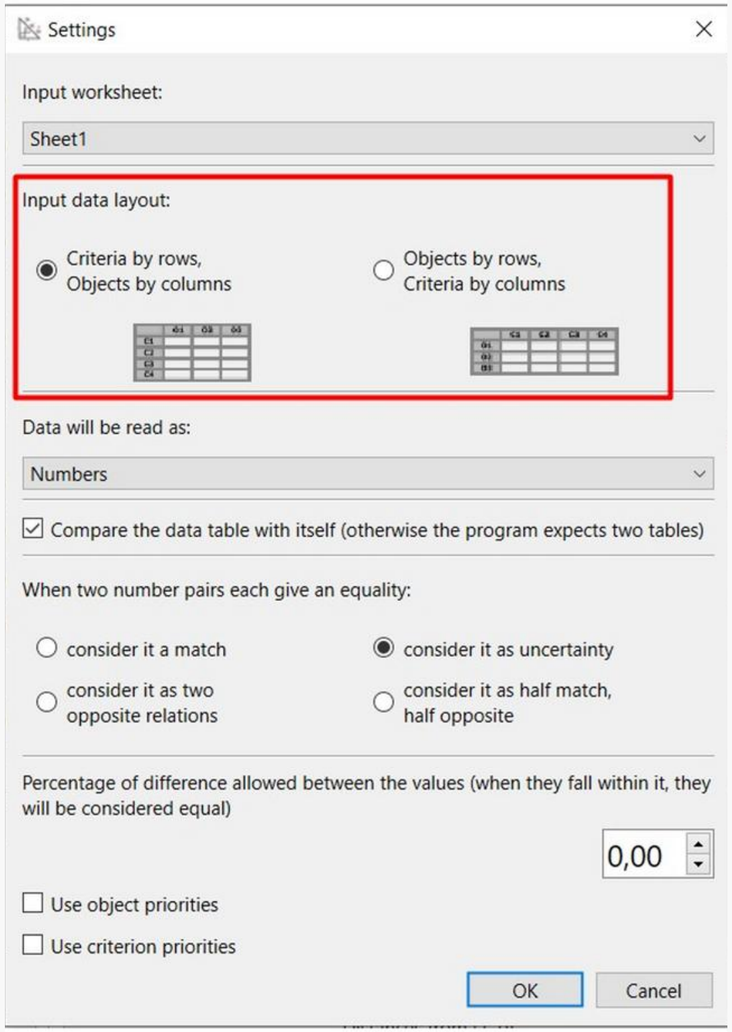

Fig.4 Input settings

After selecting a file, the Settings window is displayed (Fig.4). In the section Input data layout, the user needs to select whether the criteria in the input file are listed in columns or in rows. If the wrong layout is selected, the objects will be treated as criteria.

Comparison by countries

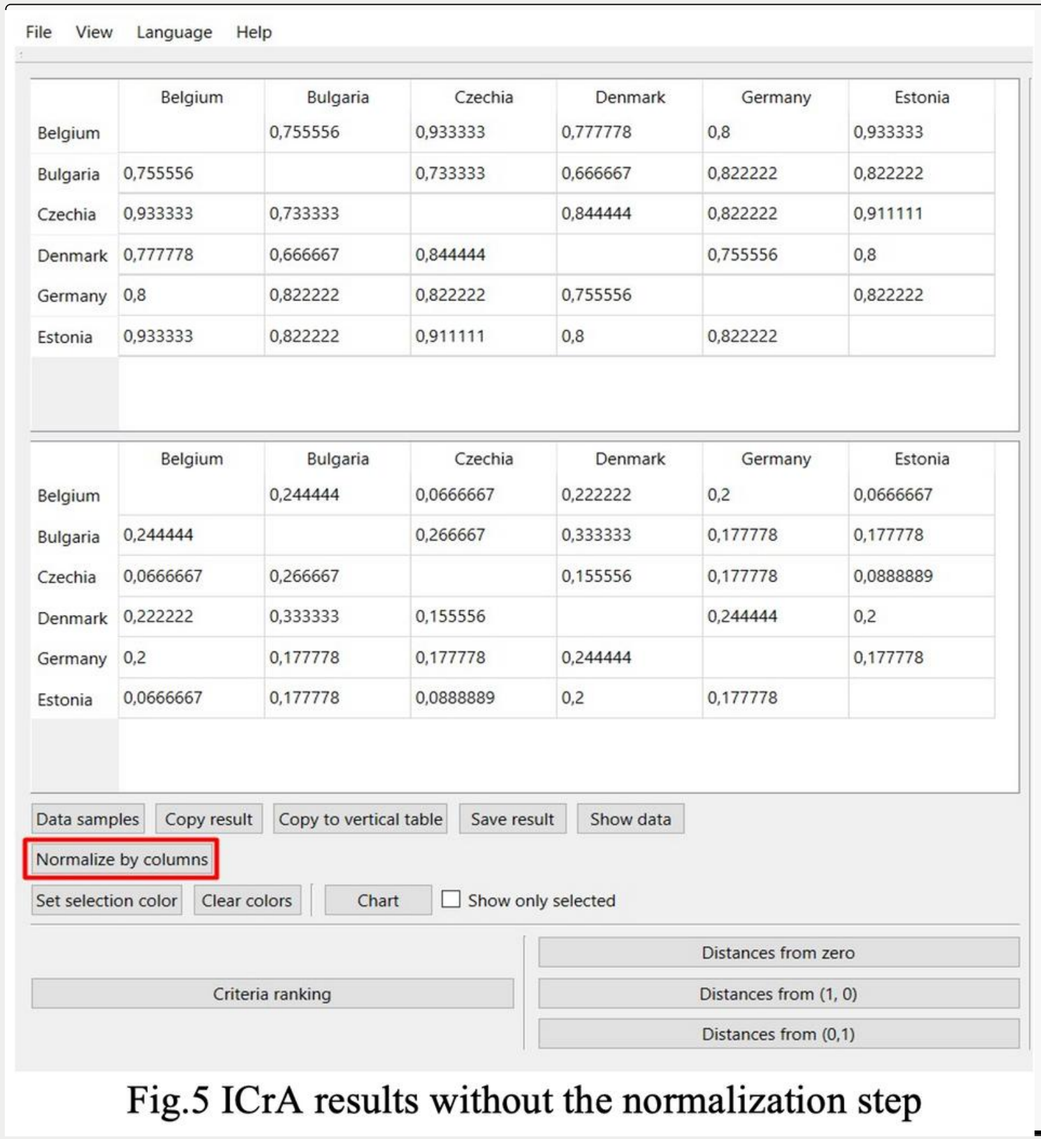

Fig.5 ICrA results without the normalization step

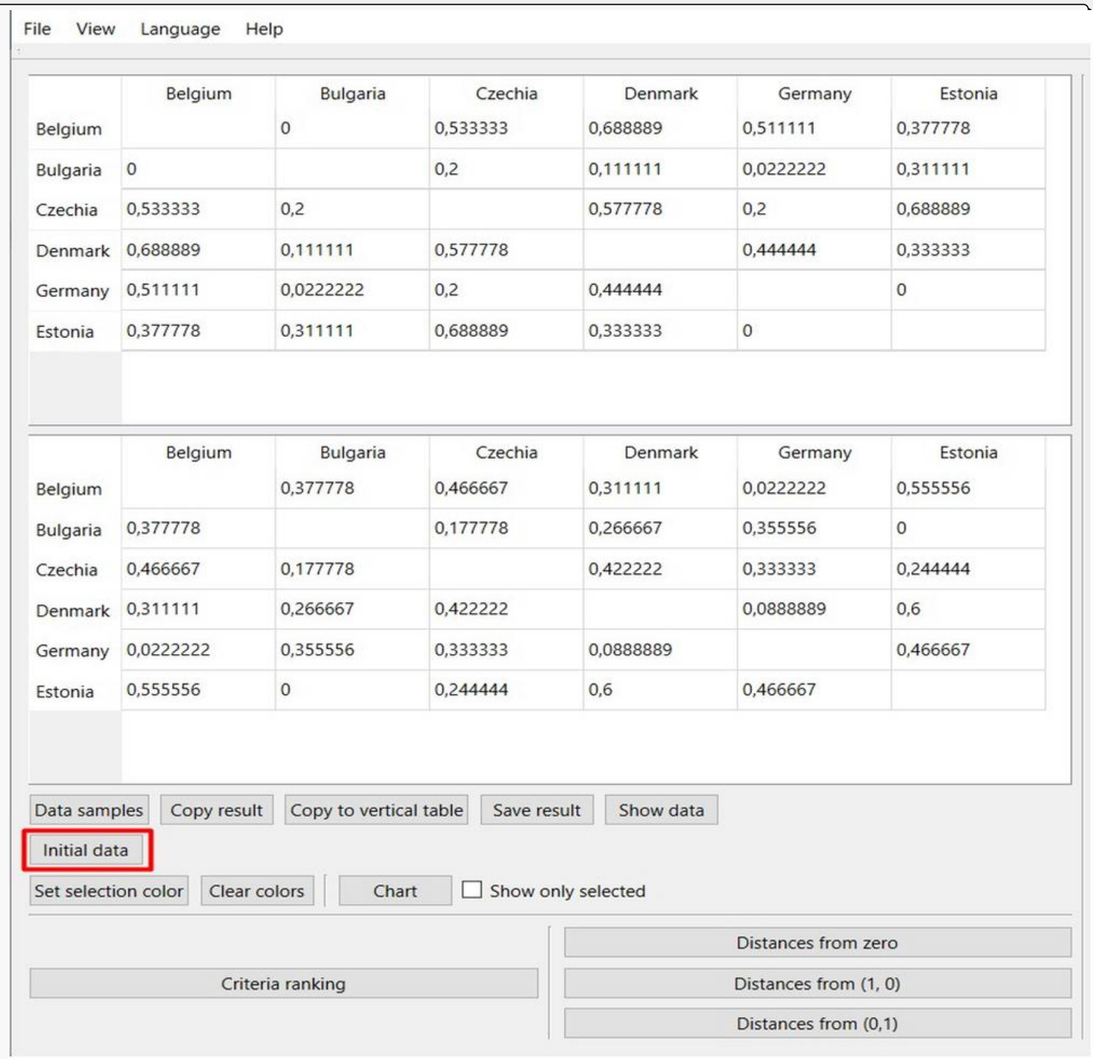

Fig.6 ICrA results with normalization step– ICrA by countries

Comparison by years

File View Language Help

	2010	2011	2012	2013	2014	2015	2016	2017	2018
2010		0,6	0,666667	0,8	0,666667	0,733333	0,666667	0,733333	0,733333
2011	0,6		0,933333	0,533333	0,933333	0,866667	0,933333	0,333333	0,866667
2012	0,666667	0,933333		0,6	1	0,933333	1	0,4	0,933333
2013	0,8	0,533333	0,6		0,6	0,666667	0,6	0,666667	0,666667
2014	0,666667	0,933333	1	0,6		0,933333	1	0,4	0,933333
2015	0,733333	0,866667	0,933333	0,666667	0,933333		0,933333	0,466667	1

	2010	2011	2012	2013	2014	2015	2016	2017	2018
2010		0,4	0,333333	0,2	0,333333	0,266667	0,333333	0,266667	0,266667
2011	0,4		0,0666667	0,466667	0,0666667	0,133333	0,0666667	0,666667	0,133333
2012	0,333333	0,0666667		0,4	0	0,0666667	0	0,6	0,0666667
2013	0,2	0,466667	0,4		0,4	0,333333	0,4	0,333333	0,333333
2014	0,333333	0,0666667	0	0,4		0,0666667	0	0,6	0,0666667
2015	0,266667	0,133333	0,0666667	0,333333	0,0666667		0,0666667	0,533333	0

Data samples | Copy result | Copy to vertical table | Save result | Show data

Normalize by columns

Set selection color | Clear colors | Chart | Show only selected

Criteria ranking

Distances from zero

Distances from (1, 0)

Distances from (0,1)

Fig.7 ICrA results without normalization step – ICrA by years

File View Language Help

	2010	2011	2012	2013	2014	2015	2016	2017	2018
2010		0	0	0	0	0	0	0	0
2011	0		0,266667	0,4	0,0666667	0,2	0,4	0,0666667	0,333333
2012	0	0,266667		0,8	0,6	0,666667	0,533333	0,533333	0,6
2013	0	0,4	0,8		0,4	0,733333	0,733333	0,6	0,8
2014	0	0,0666667	0,6	0,4		0,666667	0,4	0,666667	0,466667
2015	0	0,2	0,666667	0,733333	0,666667		0,733333	0,733333	0,8

	2010	2011	2012	2013	2014	2015	2016	2017	2018
2010		0	0	0	0	0	0	0	0
2011	0		0,333333	0,2	0,533333	0,4	0,2	0,533333	0,266667
2012	0	0,333333		0,2	0,4	0,333333	0,466667	0,466667	0,4
2013	0	0,2	0,2		0,6	0,266667	0,266667	0,4	0,2
2014	0	0,533333	0,4	0,6		0,333333	0,6	0,333333	0,533333
2015	0	0,4	0,333333	0,266667	0,333333		0,266667	0,266667	0,2

Data samples | Copy result | Copy to vertical table | Save result | Show data

Initial data

Set selection color | Clear colors | Chart | Show only selected

Criteria ranking

Distances from zero

Distances from (1, 0)

Distances from (0,1)

Data has been read for 6 objects

Fig.8 ICrA results with normalization step – ICrA by years

Results visualization

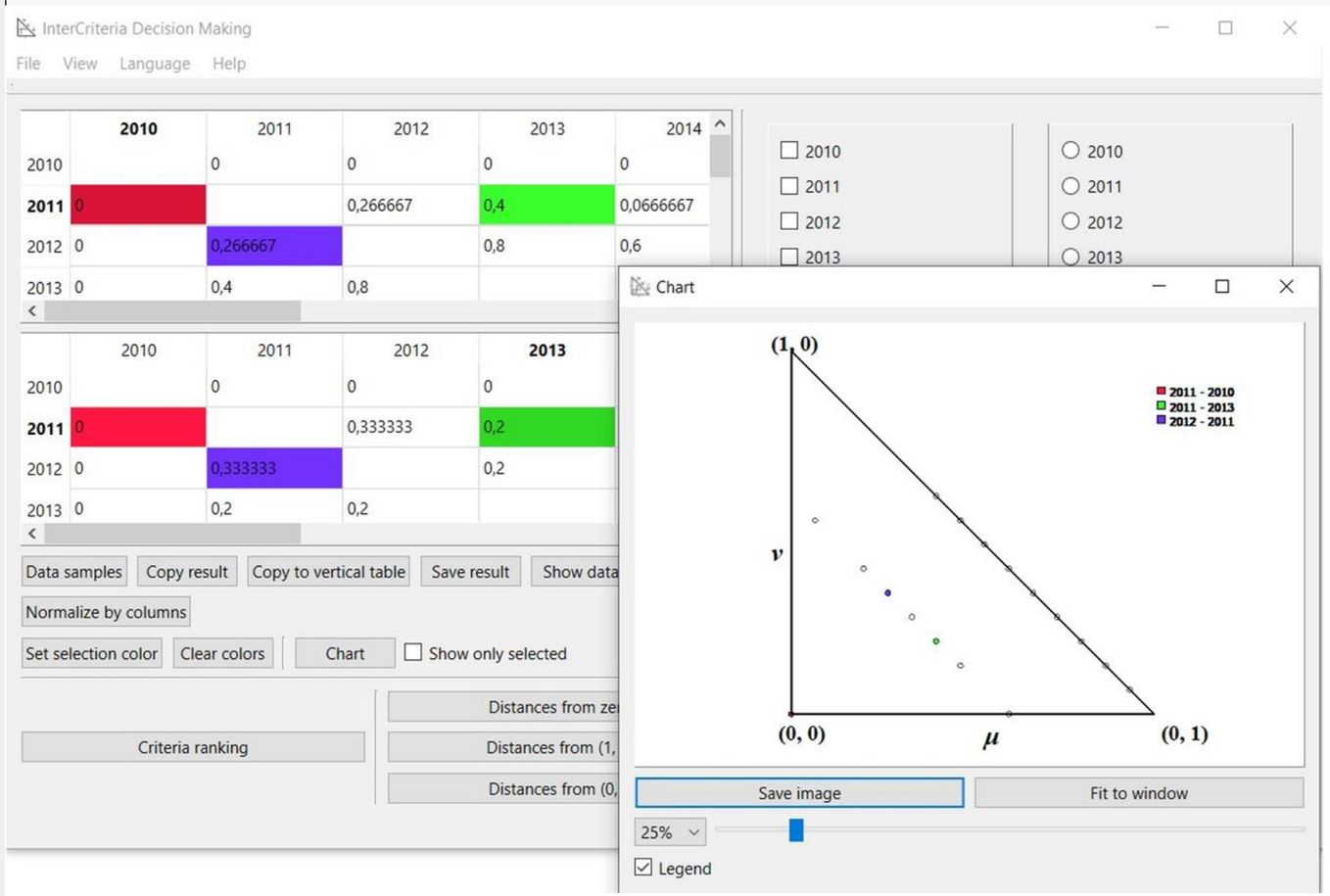

Fig.9 ICrA results visualization – display data points with colors

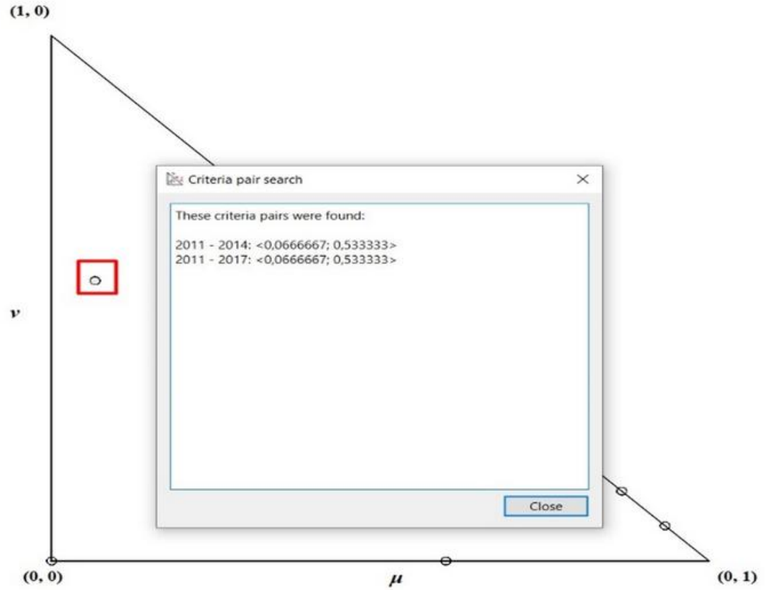

Fig.10 ICrA results visualization – information about a selected data point

Data input

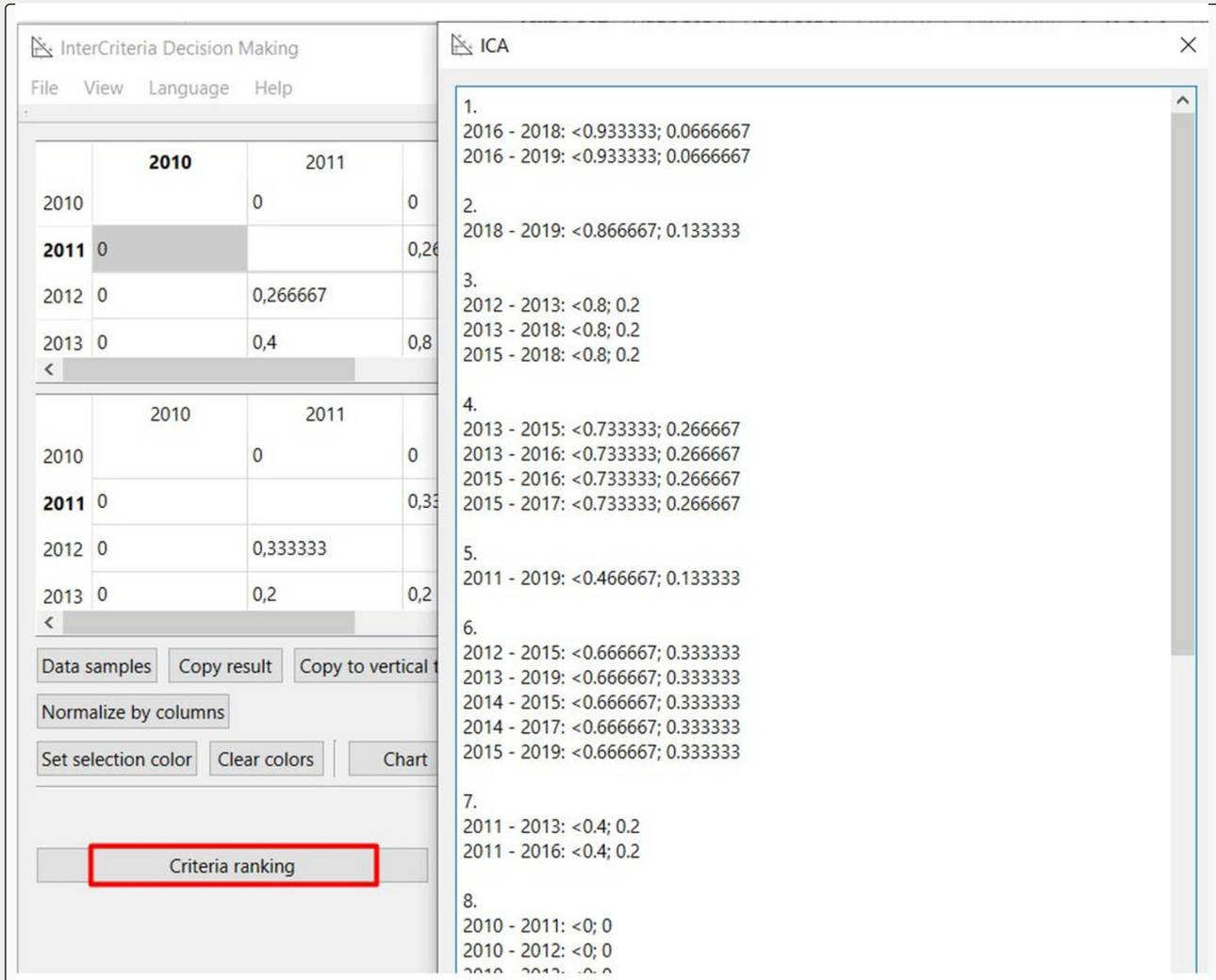

Fig.11 ICrA results visualization – criteria ranking

The results are presented in a list ordered by their degrees of membership and non-membership. The thus obtained results can be used to describe and analyze their correlations.

Conclusion

Thank you!

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