Integration of decision aid tools in a Geographical Information System

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1. Introduction
2. Methodology
3. Implementation
4. Inference
5. Demonstration
6. Conclusion
GIS and MCDA

- GIS are used in lot of application from land suitability problem to geomarketing
- Since 90’s, works about GIS and MCDA
- Not a lot of work based on ELECTRE methods
- ELECTRE methods fit well for ordinal problems
Limitations of GIS-MCDA works according to S. Chakhar:

- Weak coupling
- One MCDA method integrated (Single criterion synthesis)
- Choice of the MCDA method
- User’s knowledge of GIS and MCDA
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We add an extra one:

A good number of GIS-MCDA tools were abandoned or never surpassed the stage of prototype. Moreover it has been done in commercial GIS.
Objectives of our GIS-MCDA integration

First objectives

- ELECTRE TRI implementation
- Tight coupling
- User friendly interface
- Open Source GIS (and implementation)
Objectives of our GIS-MCDA integration

First objectives

- ELECTRE TRI implementation
- Tight coupling
- User friendly interface
- Open Source GIS (and implementation)

Second objectives

- Learning of parameters
- Implementation of a XMCDA webservice
- Experimentations
- Coupling with the ELECTRE TRI plugin
ELECTRE TRI

Parameters
- weights
- profiles
- credibility threshold
- ...

Approach
- Classical
- Bouysou-Marchant

Major interests
- Judge an action independently from the others
- Allow to consider more actions than other ELECTRE methods
- Reference values fixed : profiles
Subject

Quebec city wants to create a program to densify its population in the centrum and around the small crown. The program consists to build rental properties at low prices for young families in empty areas.

Objectives

- Densify central sectors where there are more public transports
- Sustain a good social diversity by choosing in priority the sectors where young people and immigrants are not well represented
- Favor sectors with a lot of small shops
Application: Densification of Quebec City

Decision map
### Application: Densification of Quebec City

### Definition of the problem

#### Actions

- 786 districts (polygons)

#### Criteria

- Density of 0-14 years old [%] (min)
- Density of shops [shops/ha] (max)
- Density of people [residents/ha] (min)
- Level of public transports (average) [bus/hour] (max)
- Ratio of immigrants [%] (min)
### Application: Densification of Quebec city

#### Performance table

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[Quantum GIS: Screenshot of the densification tool]
Strategy of integration

Reference

Coupling strategy
- Malczewski (2006) reports only 10% of works using a strategy of tight coupling of the MCDA method in the GIS
- Tight coupling

Actions and criteria
- Vector layer
- actions = points, lines, polygons
- criteria = attributes
Strategy to build the decision map

Step 1: Construction of criterion maps

Step 2: Construction of the multicriteria map

Step 3: ELECTRE TRI model

Step 4: Generation of the decision map
Choice of the GIS

Requirements

- Open Source GIS and implementation
- User friendly interface
- Support of vector layer
- With map algebra tools
## Choice of the GIS

**Requirements**
- Open Source GIS and implementation
- User friendly interface
- Support of vector layer
- With map algebra tools

**Lot of open source GIS**
- GRASS, PostGIS, Quantum GIS
- [http://opensourcegis.org/](http://opensourcegis.org/)
Quantum GIS

Characteristics

- Great portability (Linux, Windows, Mac OS)
- Plugin mechanism
- Lot of functionalities (GRASS, map algebra, ...)
- User-friendly interface
ELECTRE TRI plugin
Tight coupling
ELECTRE TRI plugin

User interface
ELECTRE TRI plugin
User interface
ELECTRE TRI plugin

User interface
XMCDA webservice

Characteristics

- Based on A. Leroy master thesis (2010)
- Learning of ELECTRE TRI Bouyssou-Marchant parameters
- Accept non-admissible set of learning alternatives
- Maximize number of compatible alternatives
- MIP problem
- Use GLPK
First conclusions

- Lot of learning alternatives needed to get good results
- Difficult to get good set of params when learning set not completely compatible with ELECTRE TRI model
- Computing time becomes huge when number of learning alternatives increases
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**New experimentations**

- Two step inference
- Partial inference
- Improve objective of the inference program
ELECTRE TRI BM inference webservice update

Characteristics

- Two entries added to do partial inference of the weights and lambda threshold
- Two entries added to do partial inference of the profiles
Webservice available in diviz
Coupling of XMCDA webservice with Quantum GIS
ELECTRE TRI plugin
It’s time for the demo...
Original model
Actions of reference
Global inference
Global inference (difference)

± 29% of invalid affectations
Profiles inference
Profiles inference (difference)

± 33% of invalid affectations
Weights and lambda inference
Weights and lambda inference (difference)

± 6% of invalid affectations
Conclusion

- Full open source solution running on several OS
- Good reviews during the two Decision Deck workshops
- Limitations of GIS-MCDA overcome
- Several spatial decision problems treated
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Ideas for improvements

- Plot of the profiles in the plugin
- Add the possibility to choose a spatial entity by clicking on it in the inference module
- Replacement of GLPK by SCIP as solver in webservice
- Metaheuristic to infer parameters
- Algorithm to choose an optimal learning set
Thank you for your attention!