Decider -- A Fuzzy Multi-Criteria Group Decision Support System

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Research Interests of DeSI Lab

- Textile industry
- Nuclear info. magt
- E-government
- Power market

Application level: E-service intelligence, personalization, web data integration, early warning systems, resource planning & evaluation

Technical level: intelligent decision models, algorithms, methods and support system software

Fundamental level: Uncertain information processing, fuzzy logic & optimization, data missing and reasoning
• Fuzzy multi-objective decision approaches
• Group decision methods in an uncertain environment
• Bi-level/Tri-level multi-followers decision making methods
• Rule-sets based bilevel models and algorithms
• Case-based reasoning prediction approaches
• Situation awareness and cognitive decision support models
• Web data integration and matching approaches
• Personalized recommendation methods
• Hybrid genetic & particle swarm optimization algorithms

(ARC 2002-2004) ‘Group decision support systems for fuzzy multi-objective decision problem’
(ARC 2005-2007) ‘Uncertain information processing for situation awareness and dynamic decision-making in emergency management’
(ARC 1/2008-12/2010) ‘A comprehensive platform for dynamic decision support in warning systems through better uncertain information management’
Decision support systems (DSS) developed

• Fuzzy multi-objective decision support system (FMOGDSS)
• Web-based fuzzy group decision support system (WFGDSS)
• Fuzzy multi-criteria (group) decision support system (Decider)
• Bi-level decision support system (FBLDSS)
• Personalised recommender system for E-government (G2B) services
• Cognition oriented decision support system (FACETS)
Application developments

Belgian long-term sustainable energy (nuclear) strategy and safeguards

Nonwoven materials design and development

Well-being garment new product development evaluation (France)

Bilevel optimization in power market (electricity price/demand), transportation & logistics
FMOSSS: Nonwoven materials design

Fuzzy Multi-Objective Decision Support System

With the Book "Multi-Objective Group Decision Making: Methods, Software and Application with Fuzzy Set Techniques"

Authors: Jie Lu, Guangquan Zhang, Da Ruan and Fengjie Wu

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The FMOSS method was called.
FACETS: business intelligence
Decider focuses on three-level structure, which includes criteria, experts, and information sources.

- Criteria: which aspects to be considered for a decision
- Experts: who presents opinions
- Information sources
Background

- Main features in complex and dynamic decision-making situations
  - **Group decision making**
    - Hierarchy of decision makers
  - **Multiple criteria**
    - Hierarchy of criteria
  - **Difference data sources**
    - Subjective & objective data
  - **Uncertain and linguistic information processing**
    - Information sources with different believe degrees
    - Decision makers have different weights using linguistic terms
    - Assessment scores using linguistic terms
• **Uncertainty and linguistic information processing**
  – *Decider* can partially handle uncertainty and linguistic information by using the fuzzy set techniques.

• **Methods integration**
  – *Decider* integrates a set of group decision-making methods.
  – *Decider* provides an operator-base and a method-base.

• **Flexible structure**
  – *Decider* uses trees to describe criteria hierarchy and evaluator hierarchy.
  – *Decider* can handle linguistic terms, boolean values, and numeric values
  – *Decider* implicitly/explicitly considers information sources.
Input (subjective & objective) and output

Decision makers’ evaluation

Objective evaluation

Fabric samples \( S_1, S_2, \ldots, S_m \)

Evaluator

Machine

Data fusion method

Final ranking on \( S_1, S_2, \ldots, S_m \)

Aspects/criteria \( C_1, C_2, \ldots, C_t \)

score

weight

measurement

weight

Input (subjective & objective) and output
Structures (information flow)

- Hierarchy of experts
  - Real experts
  - Virtual experts

- Data sources

- Fuzzification

- Aggregation
  - Stage 1
    - Aggregation on leaf criteria
    - Aggregation on non-leaf criteria

- Ranking

- Decision information
  - Assessments
  - Decision references
  - Overall assessments
  - $T_o$
The main modules:

- Input/Output module
- Function implementation module
- Resources management module
- Analysis & Comparison module
Step 1: identify alternatives.
Step 2: identify hierarchy of criteria and their weights.
Step 3: identify evaluators and their weights.
Step 4: identify information sources and its connection with criteria.
Step 5: collect information from information sources.
Step 6: evaluators give options to generate initial decision matrix for each alternative.
Step 7: apply fuzzification method to the assessments in an initial decision matrix.
Step 8: apply a fuzzy aggregation method to obtain overall assessment on each alternative.
Step 9: generate ranking for alternatives by the fuzzy aggregation method and related ranking strategy.
### Linguistic terms

<table>
<thead>
<tr>
<th>Decision makers’ wrights</th>
<th>Evaluation values from evaluators</th>
<th>The importance degrees of criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Lowest</td>
<td>Absolutely unimportant</td>
</tr>
<tr>
<td>Important</td>
<td>Very Low</td>
<td>Unimportant</td>
</tr>
<tr>
<td>More important</td>
<td>Low</td>
<td>Less important</td>
</tr>
<tr>
<td>Most important</td>
<td>Medium</td>
<td>Important</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>More important</td>
</tr>
<tr>
<td></td>
<td>Very High</td>
<td>Strongly important</td>
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<tr>
<td></td>
<td>Highest</td>
<td>Absolutely important</td>
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<td>------------------------</td>
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</tr>
<tr>
<td><strong>Product 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>very high</td>
<td>high</td>
</tr>
<tr>
<td>Density</td>
<td>low</td>
<td>lowest</td>
</tr>
<tr>
<td>Extensibility</td>
<td>very low</td>
<td>lowest</td>
</tr>
<tr>
<td>Compressibility</td>
<td>low</td>
<td>lowest</td>
</tr>
<tr>
<td>Flexibility</td>
<td>very low</td>
<td>very high</td>
</tr>
<tr>
<td>Resilience</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Surface friction</td>
<td>very low</td>
<td>very low</td>
</tr>
<tr>
<td>Surface contour</td>
<td>very high</td>
<td>medium</td>
</tr>
<tr>
<td>Thermal-wet sensation</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td><strong>Product 2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>lowest</td>
<td>low</td>
</tr>
<tr>
<td>Density</td>
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Application 1: Belgian energy policy assessment

- It is an application in the cooperation with Belgian Nuclear Research Center (SCK-CEN).
- This application
  - Aims to rank 8 policies/scenarios
  - Has 10 experts/evaluators
  - Establishes three level of criteria
  - Has data with different ranges
  - Contains lots of missing data (N/A, I don’t know, not sure..)
Belgian Energy Policies
There are 4 aspects (Aspect 1)
Each has several criteria

Application 1:
Application 1:

The tree-like multiple-level Hierarchy of criteria.
Application 1:

The overall assessments of ten experts.
Application 1:

The assessment of the second evaluator on criteria “Environment and human Health”
Application 2: 

new fashion product development

This application is in the cooperation with Ecole Nationale Supérieure des Arts et Industries Textiles (ENSAIT), Roubaix, France.

It
- deals with new fashion product development under the concept of well-being
- deals with both machine measurements data and evaluators’ values
- has a set of product prototypes to be evaluated
- has multi-level multi-criteria for the evaluation
- has a group of evaluators with individual weights
- evaluators give their assessment by linguistic terms
- aims to rank these product prototypes
Application 2: evaluators

Evaluator

Designer Group
- Designer 1
- Designer 2
- Designer 3

Marketing Group
- Marketing Manager 1
- Marketing Manager 2
Application 2: criteria input

• Three-level multi-criteria
• Having different weights
• Using different range
Application 2

Step 1: In this step, you can set criteria in a tree structure. The ROOT node is used to indicate the overall problem. Any non-leaf node in this tree is treated as an aspect. Any leaf node is the real and concrete criterion.

- Fashion style
  - Health
  - Serenity
  - Pleasure
  - Relaxation
  - Cocooning
- Dynamism
  - Sport
  - Pleasure
  - Relaxation
  - Warmth
    - Health
    - Sport
    - Serenity
    - Pleasure
    - Holiday
    - Relaxation
    - Cocooning
- Coolness
- Functional properties
  - Fabric Hand
  - Smell
  - Sound

Criteria:
- Name: Warmth
- Strength: Absolutely important (Linguistic-Weight)
- Description: Warmth is about the state, sensation, or quality of producing or having a moderate degree of heat, friendliness, kindness, or affection.
Objective criteria settings.

Application 2

Criterion Setting

Basic Information

Name: Compressibility

Ref. Code:

Data Type:

- subjective
- true/false
- range

Type: Linguistic-Weight

Description: Compressibility

upper boundary: 1.0
lower boundary: 0.0
preference: 0.5

strength: Strongly important

Reverse Rank: 

Cancel Apply
Application 2

Overall assessment result
Product C is the best one
Overall assessment based on Virtual Expert which Representatives objective values.
Decider is a powerful decision-making and evaluation software tool. Decider can deal with:
- Subjective and objective data
- Linguistic data and numerical data
- Data with different ranges
- A set of decision makers (decision group) with different weights
- A set of alternatives
- Multi-level criteria with different weights
- Aggregate all evaluation data and find the “Best” option.

Decider can be used in different domains:
- emergency management evaluation
- risk level evaluation
- strategy evaluation
- performance evaluation and any other alternatives-based decision

It can combine with other decision support system tools for more complex situations.
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