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Interactive Decision Support within Corporate Environmental Management Information Systems

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Outline

I. Motivation and Background

II. Literature Review

III. Decision Support System
   i. Ideal and Nadir Points
   ii. Interactive Features
   iii. Explanation System

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Decision Support within Corporate Environmental Management Information Systems (CEMIS)

- "[…] organizational-technical system for systematically obtaining, processing and making environmentally relevant information available in companies"
- Existing systems achieve legal compliance but do not provide strategic alignment
- CEMIS should aim to find and optimize processes regarding their environmental impacts
- The EU-Project „IT-for-Green" develops a CEMIS of the next generation integrating a strategic focus for small and medium sized enterprises (SMEs)
  - This requires the implementation of a decision support tool
  - Example: "Which production technologies are more sustainable?"

IT-for-Green

EUROPÄISCHE UNION
Europäischer Fonds für regionale Entwicklung

Europa fördert Niedersachsen

cf. Teuteberg/Gómez 2010

Design Requirements

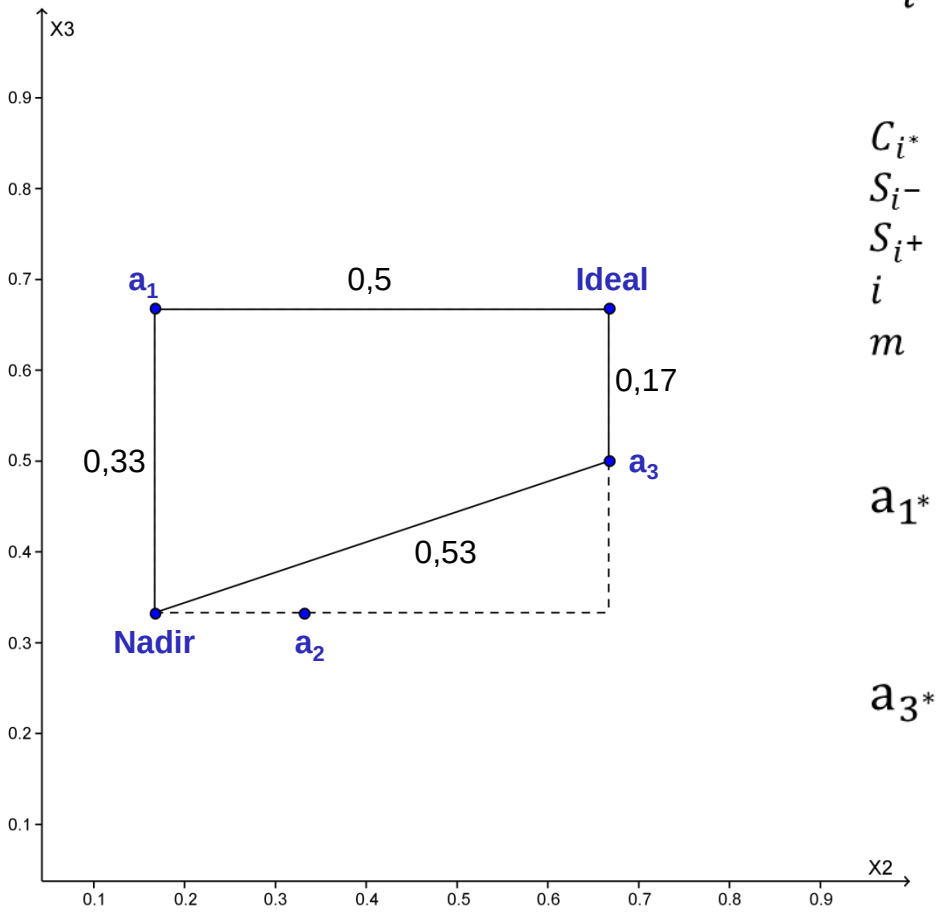
- Applicable without the presence of a human analyst
  - easy to understand
  - not based on an explicit value/utility function
  - as few as possible “non-intuitive” user inputs
  - familiarize the decision maker with the decision problem

- Decision support for a finite number of alternatives
- Group Decision Support

Literature Review

- Ideal and Nadir Points in Decision Support:
  - Decision Support based on Euclidean Distances (Hwang/Yoon, 1981)
  - User set aspiration levels acting as ideals (Lofti/Stewart/Zionts, 1992)
  - Decision Support is always dependent on reference points (Zeleny, 2011)
- Interactive Decision Support:
  - Constantly changing aspiration levels as input (Lofti/Stewart/Zionts, 1992)
  - Decision Making based on alternatives that differ in two criteria (Larichev/Moshkovich, 1995)
- Explanation Systems:
  - Increase trust and confidence of final solutions (Geldermann, 2010)

Decision Support based on Ideal and Nadir Points



$$C_{i^*} = \frac{S_{i^-}}{(S_{i+} + S_{i-})}, 0 < C_{i^*} < 1, i = 1,2, \dots, m$$

C_{i^*}	Relative closeness to ideal solution
S_{i^-}	Separation measure of i to Nadir
S_{i^+}	Seperation measure of i to Ideal
i	Alternative i
m	Number of alternatives

$$a_{1^*} = \frac{0.33}{(0.5 + 0.33)} \approx 0{,}3976$$

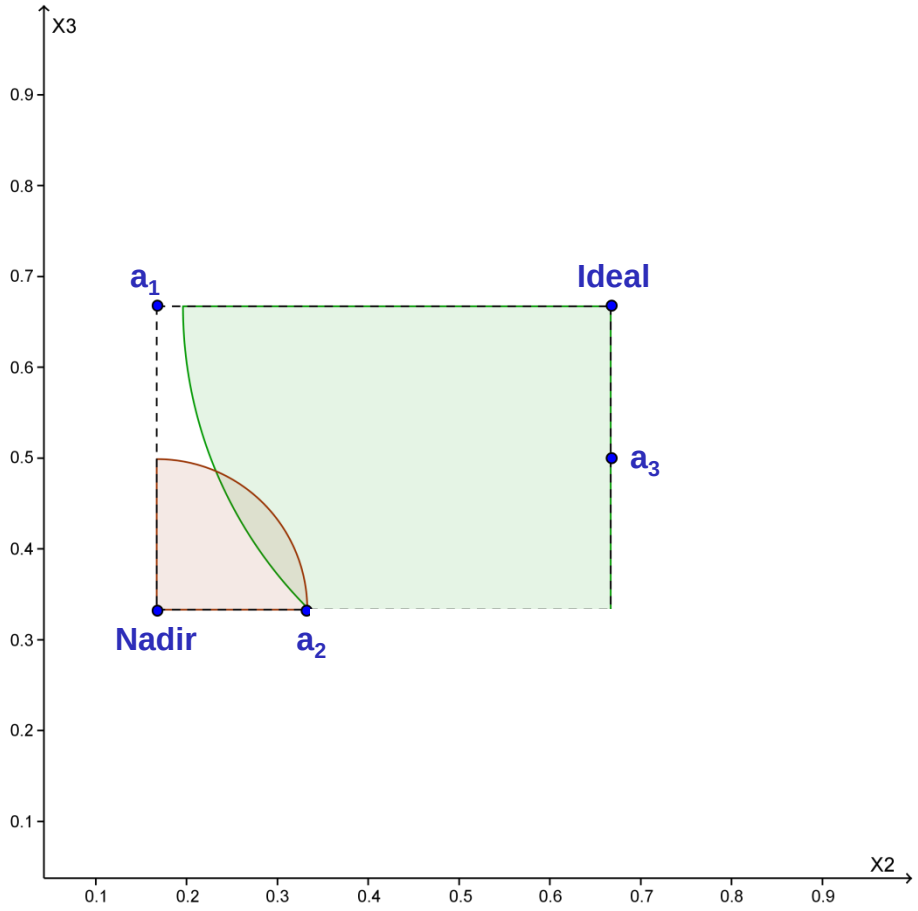
$$a_{3^*} = \frac{0.53}{(0.17 + 0.53)} \approx 0.7571$$

cf. Hwang/Yoon 1981

What characterizes an interactive method?

- Principles:
  - Continuous (iterating) human-human/-machine dialog
  - Information gathering during the application of the method
  - Not only the (final) solution matters, but also the way it is obtained
- Leads to:
  - Confidence in the final solution
  - Familiarity of the decision maker to the decision problem
  - More time spent

User input in cases of incomparabilities



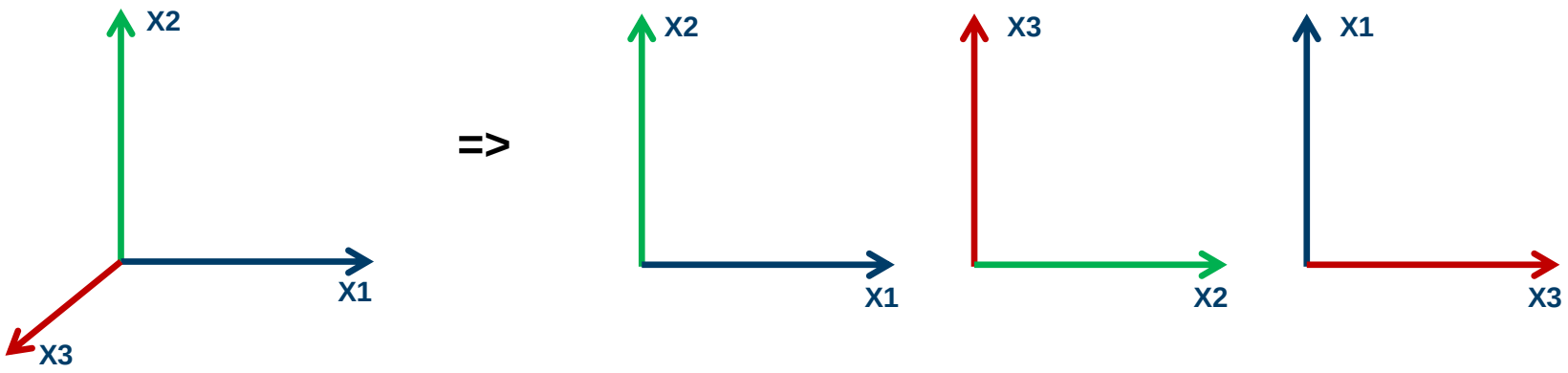
X2/X3	a_1	a_2	a_3
a_1	0	**?**	-1
a_2	**?**	0	-1
a_3	1	1	0

0: Row = Column; 1: Row $\succ$ Column;
-1: Row $\prec$ Column; ?: Incomparability

- a1 = a2
- a1 $\succ$ a2
- a1 $\prec$ a2

Decomposition of the Decision Problem

- The n-dimensional decision problem will be divided into $\frac{(n-1)\cdot n}{2}$ two-dimensional spaces for pairwise comparisons
- Each two-dimensional space is represented by a $A \times A$ matrix
- Based on Euclidean measures the method will fill out each matrix except for incomparabilities



Assessing Indifference, Preference and Incomparability

Indifference

- a*I*b, if $\left[(max_x - a_x)^2 + (max_y - a_y)^2\right]^{\frac{1}{2}} = \left[(max_x - b_x)^2 + (max_y - b_y)^2\right]^{\frac{1}{2}}$

and

$\left[(min_x - a_x)^2 + (min_y - a_y)^2\right]^{\frac{1}{2}} = \left[(min_x - b_x)^2 + (min_y - b_y)^2\right]^{\frac{1}{2}}$

Preference

- a*P*b, if $\left[(max_x - a_x)^2 + (max_y - a_y)^2\right]^{\frac{1}{2}} < / \leq \left[(max_x - b_x)^2 + (max_y - b_y)^2\right]^{\frac{1}{2}}$

and

$\left[(min_x - a_x)^2 + (min_y - a_y)^2\right]^{\frac{1}{2}} \geq / > \left[(min_x - b_x)^2 + (min_y - b_y)^2\right]^{\frac{1}{2}}$

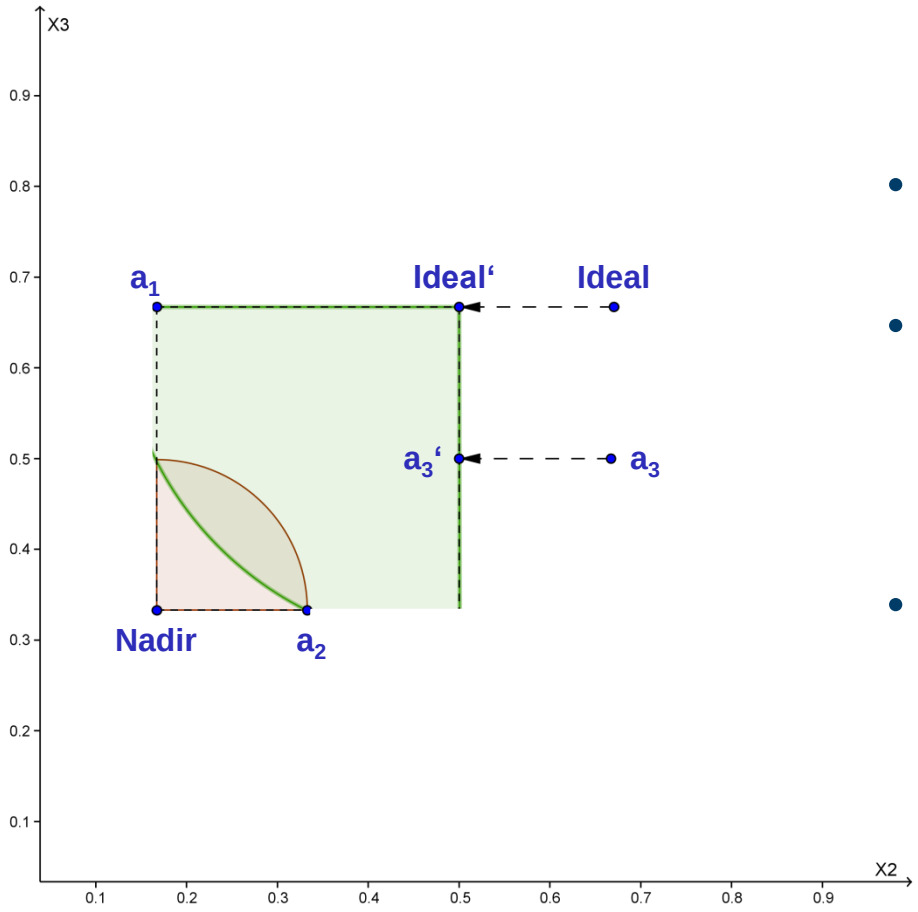
Incomparability

- a*N*b, if $\left[(max_x - a_x)^2 + (max_y - a_y)^2\right]^{\frac{1}{2}} < / > \left[(max_x - b_x)^2 + (max_y - b_y)^2\right]^{\frac{1}{2}}$

and

$\left[(min_x - a_x)^2 + (min_y - a_y)^2\right]^{\frac{1}{2}} < / > \left[(min_x - b_x)^2 + (min_y - b_y)^2\right]^{\frac{1}{2}}$

User input in form of aspiration levels



- Additional preference type => Saturation
- Manual adjustment of reference points
  - Constraining outliers
  - Dissolution of incomparabilities
- Results will be updated “on the fly”

Improving trust in the final decision

- Explanation systems influence user perceptions such as:
  - Trust, confidence, satisfaction levels of acceptance and learning
- Reasoning explanations
  - "While the *criterion 'resources'* is the main reason to prefer *Alternative B*, this is outweighed by considerations of the *criterion 'impact'*, along with other less important factors, that provide reasons for preferring *Alternative C*."
- Sensitivity Analysis Explanations
  - "You may change the weight of the *criterion 'resources'* from 14.5% to 22% without causing a rank-reversal."

cf. Geldermann 2010

Outlook

- Completion of the method:
  - Weighting
  - Coordination of group decision processes
  - Stability tests
- Benchmark with a real case study
- Integration in the MCDA software
  - Extend the current software with the interactive method

Summary

- SMEs require special kind of decision support
  - Easy to understand and trustworthy results
- None of the well-known approaches seem to be applicable
- The interactive system as presented can fulfill those requirements
  - Based on Euclidean distances and adjustable reference points
  - Integrated explanation system
- The implemented system will be used as a Web-Service for the IT-for-Green project