Cognitive Aspects of Multicriteria Decision Making and the Theory of Freedom of Choice

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Real-Life Motivations (I):

- How much decision freedom can be given to Artificial Autonomous (Decision) Systems (AADS)? And how should it be determined in each real-life situation?
- Solutions to the decision problems with quickly changing set of admissible alternatives and/or changing attributes or criteria
  Example: choice of a flight when seats in a selected price class may got overbooked reluctantly and/or prices change in real time
  Solution: explore psychological and social decision patterns rather than use optimal stopping theory
- Modelling consequences of a decision made taking into account various future scenarios, contexts, aspects, and exposure to risk ['world models', games with environment]

Specific areas of research underlying the decision freedom

Interdisciplinary research on:

- Neural, psychological, and social decision-making mechanisms, the decision support systems architectures and interfaces, which adapt to the neural mechanisms or follow them in an optimal way;
- Philosophical, metamathematical,and teleological interpretations of decision-making processes
- Innovative algorithms of multicriteria optimisation and cooperative games dedicated to solve selected classes of complex temporal decision problems, such as problems of strategic planning, dynamic prioritisation and rankings, multicriteria choice in a dynamic environment

The notion of Freedom of Choice (FOC) - preliminaries

The playground – decision subjects:

- Human decision-making
- Autonomous Decision Systems
- Intelligent Intention-Understanding systems – a new subclass of Cognitive DSS

The playground – decisions:

- Conditionally Rational Decisions vs. Pareto-optimality w.r. to a given set of criteria,
- Where to choose from: soft and hard constraints and real options, ability to change constraints in time and its price
- Freedom to make an irrational decision
- Freedom to set goals and define criteria

Principal Applications

New ideas and approaches allow to carry out detailed studies of applications in different fields, such as :

- Real-life AADS (vehicles, rescue systems, decision-making in emergency situations, robot vision)
- Financial decision support and decision-making
  (forecast-based DSS for forex and equity portfolio, energy commodities)
- Recommender systems
  (specific areas tbs, recommenders based on visual information preferred; previous proposals: holiday resort/hotel choices, multimedia etc.; new challenge: recommendations in medical expert systems

Hints and conclusions

- Cognitive mechanisms embedded in decision support systems must take into account human ability or right to make a rational decision
- Autonomous agents (*automatic decision pilots*) can be built in recommenders and other DSS to allow to make *cautious decisions* [by a 'cautious decision' one should mean the selection of an alternative which conforms maximally to the individual cognitive decision model]
- Formal models of the decision freedom are indispensable in the design and implementation of AADS.

Real-Life Motivations (II):

- Different approaches to 'learning from mistakes' and from the knowledge of previous decisions of a Decision-Maker
- Deriving a preference structure out of previous choices
  [widespread naive approaches in the web, no satisfactory theory can exist without studying the cognitive decision mechanisms]
  Principal application: cognitive recommenders
- Integrating foresight, forecasts, predictive control models, temporal databases, dynamic feature extraction and decision-making
- Dynamic rankings, time-dependent preferences, applications to derive robust decision rules in a dynamical environment

Specific areas of research underlying the decision freedom

(continued):

- New methodologies of scenario building and modelling the consequences of decisions made, based on advanced models of anticipatory systems, adaptive and predictive optimal control, controlled discrete-event systems and optimiser networks;
- Learning-based selection of multicriteria dynamic choice models based on the multi-level analysis of consequences of the selection made

Last, but not least:

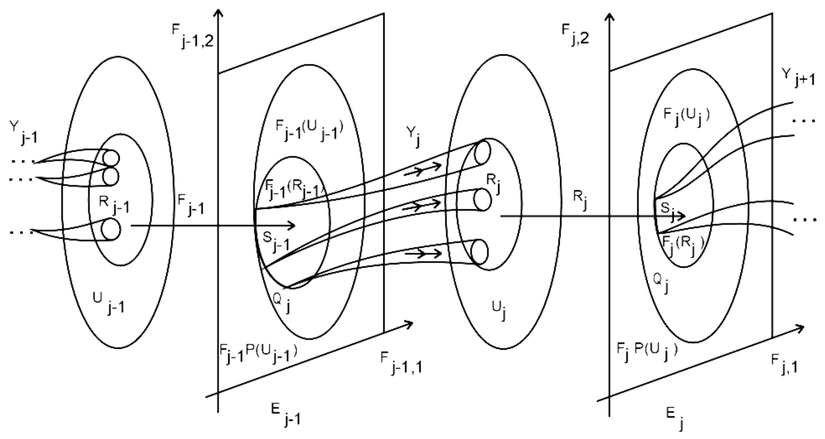
- Theory of robotic systems with different levels of autonomy to specify goals, criteria, plan tasks, and react to commands

The notion of Freedom of Choice (II)

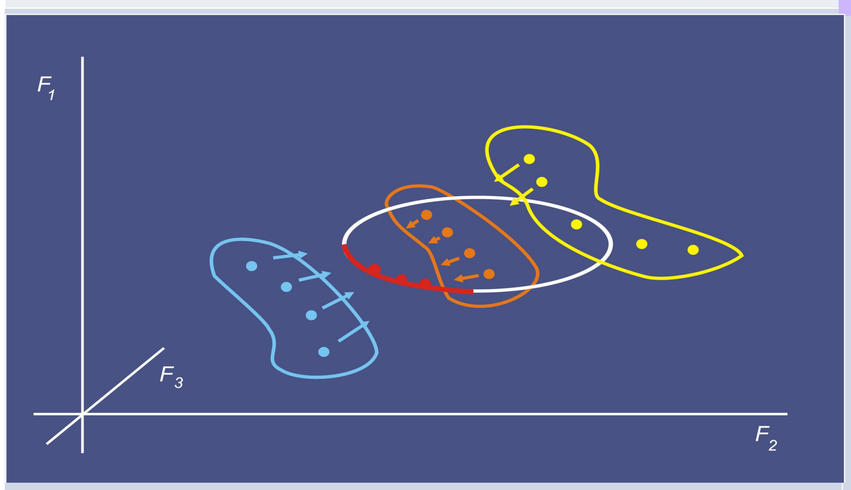
Definition1. The ***freedom of choice (FOC) of the 1st*** order, is an ability to choose when a set of choice criteria for a given set of admissible alternatives is specified,

Definition 2. The ***freedom of choice of the 2nd order***, is to allows the decision-maker to relax the constraints,

Definition 3. The ***freedom of choice of the 3rd order*** is a power to select the criteria of choice in the feature space of real-life objects, which are the subjects of decision-makers' final choice.



A model of networked multicriteria decision problems (U_j,F_j) with anticipatory feedback mechanisms, and causal multivalued dependence Y_j between the outcomes of decision problems at n-th level and the scope of admissible decisions at the next (n+1)th level



Reference values of criteria derived from the analysis of decision - makers' behaviour and from experts' judgments

Research goals:

Principal aims:

create new methodologies and approaches to solve complex real-life decision problems, where the temporal and cognitive aspects play the primary role; delegate the solution process to AADS without affecting the leading role of human supervisors

How to achieve it?

- Formalize the notion of 'freedom of decision'
- Develop the theory of AADS
- Model temporal aspects of decision support
- Model cognitive processes related to decision-making and apply them to design computer-aided decision tools
- Elaborate the effective solution methods and algorithms including a collection of new theoretical and applicable approaches

The Methodology

- Develop the theory of AADS based on the notion of decision freedom in context of human supervisors and/or 'human value system'as a superordinated authority
- Produce a bulk of specialised decision support algorithms dedicated to different classes of real-life decision problems, taking into account their cognitive and temporal aspects
- An intensive use of knowledge synthesis and representation methods.
- Develop on-line prototype expert systems, containing a.o. dynamic ranking algorithms, priority management, computing and clustering the scenarios, with an ability to manage different types of organisations, robotic systems etc.

The notion of Freedom of Choice (III)

- In real-life decision problems external preference structure and decision support procedure may also be a subject of choice in some circumstances
- The ability to choose such procedures can be another element of the *decision-making freedom*
- The freedom of choice of all above types will be attributed to the **primal decision-makers** - a basic notion modeled together with the set of relations between them by an ontology. Additional **secondary decision-makers** are able to learn from their past decision experience

Freedom to set reference values of criteria

Reference sets are defined as sets of characteristic points in the criteria space with similar levels of utility. There are four basic types of reference sets:

- A_0 – bounds of optimality – borders of an area where optimisation makes sense,
- A_1 – *target points* – goals of optimisation,
- A_2 – *status quo solutions* – available solutions, which should be improved in optimisation process or lower bounds of the set of satisfactory solutions,
- A_3 – *anti-ideal points* – solutions to avoid.

All of them can be further split into subclasses.

Further inquiries and contact are welcome:

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