

Salvatore Greco, Ricardo Alberto Marques Pereira, Massimo Squillante,
Ronald R. Yager, and Janusz Kacprzyk (Eds.)

Preferences and Decisions

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Preferences and Decisions

Models and Applications

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This volume is dedicated to Professor Mario Fedrizzi, our distinguished colleague and dear friend, on the occasion of his 60th anniversary which was celebrated by the scientific community during the TRENTO 2009 international workshop on Preferences and Decisions, held in Trento (Italy) on April 6-8, 2009.



Professor Mario Fedrizzi received his B.Sc. in Mathematics from the University of Padua and his M.Sc. in Operational Research from the University of Venice. Since then he has been associated with the University of Trento, where he founded the Applied Mathematics group at the Faculty of Economics around 25 years ago, remaining ever since the scientific and organizational leader of the group.

Moreover, Professor Mario Fedrizzi has over the years been appointed to prominent academic positions as Head of Department, Dean of Faculty, and Vice-Rector, and has also been entrusted with prestigious top management positions within the economic community of Trento and beyond.

The TRENTO 2009 international workshop was chosen to best celebrate Professor Mario Fedrizzi's anniversary by gathering a group of top scientists to present papers in areas in which he has long been active. The international workshop has also been an excellent opportunity to celebrate the close friendship and long term research collaboration between Trento and the Catania and Naples groups coordinated respectively by Professor Benedetto Matarazzo and Professor Aldo Ventre. For this reason, the organizing committee of TRENTO 2009 was extended to our colleagues from Benevento, Catania, and Naples.

As members of an informal seminal network of distinguished Italian scholars with strong international research connections, Professors Mario Fedrizzi, Benedetto Matarazzo, and Aldo Ventre have all played for years a leading role in the study and development of fuzzy set theory in Italy and worldwide, and our research community is greatly indebted for their devotion, support, advice, and encouragement.

Preface

Decision making is an omnipresent, most crucial activity of the human being, and also of virtually all artificial broadly perceived “intelligent” systems that try to mimic human behavior, reasoning and choice processes. It is quite obvious that such a relevance of decision making had triggered vast research effort on its very essence, and attempts to develop tools and techniques which would make it possible to somehow mimic human decision making related acts, even to automate decision making processes that had been so far reserved for the human beings. The roots of those attempts at a scientific analysis can be traced to the ancient times but – clearly – they have gained momentum in the recent 50 or 100 years following a general boom in science.

Depending on the field of science, decision making can be viewed in different ways. The most general view can be that decision making boils down to some cognitive, mental process(es) that lead to the selection of an option or a course of action among several alternatives. Then, looking in a deeper way, from a psychological perspective this process proceeds in the context of a set of needs, preferences, rational choice of an individual, a group of individuals, or even an organization. From a cognitive perspective, the decision making process proceeds in the context of various interactions with the environment. On the other hand, from a normative, formal perspective, the decision making process proceeds in the context of formal tools for the representation of sets of options (alternatives), preferences and utility functions, rationality, and mathematical tools that can be employed; that is, is concerned with a logic of decision making.

The perspective assumed in this volume is mainly within the formal approach to decision making. We will present some promising new developments that can help either get a deeper insight into the traditional formal models of decision making or show new conceptual tools that may lead to new models of a greater generality, an enhanced expressive power or a better computational efficiency. The authors deal with many types of decision making settings, notably with broadly perceived decision making under uncertainty, risk, imprecision (fuzziness), etc., and use a wide array of tools including probability theory, statistics, fuzzy logic, rough sets theory, etc.

A notable feature of contributions included in this volume is that they span a whole array of topics in the sense that they include – first – works dealing with mathematical tools which are indispensable for a meaningful analysis of virtually all realistic decision making models, exemplified by the modeling of various kinds of uncertainty and imprecision of information. Second, new developments in crucial underlying elements of decision making models, exemplified by preference modeling, are discussed. Third, multicriteria and multiperson decision making

models are presented, notably those related to a crucial problem of consensus reaching. However, some papers are also included that present new mathematical tools that at present may only be viewed as a conceptually viable alternative to traditional mathematical tools. The above mentioned more basic works are complemented by a large group of papers which are concerned with the applications of various decision making models, notably in economics, finance, management, etc. Applications to problems related to new challenges related to, for instance, social networks are noteworthy.

Now, to give the reader a more detailed view of what is considered in this volume, we will present a brief description of the contents of the particular contributions in the order in which they appear. This may help the interested readers find the paper of interest.

Gianni Bosi and Romano Isler (“Continuous utility functions for nontotal preorders: a review of recent results”) present some recent and significant results concerning the existence of a continuous utility function for a not necessarily total preorder on a topological space. First, the authors recall an appropriate continuity concept, a so-called weak continuity relative to a preorder on a topological space. Then, they provide a general characterization of the existence of a continuous utility function for a not necessarily total preorder on a topological space and show some relevant consequences, for the theory and applications.

Christer Carlsson and Robert Fullér (“Risk assessment of SLAs in grid computing with predictive probabilistic and possibilistic models”) developed a hybrid probabilistic and possibilistic technique for assessing the risk of a service level agreement (SLA) for a computing task in a cluster/grid environment. The probability of success with the hybrid model is estimated higher than in the probabilistic model since the hybrid model takes into consideration the possibility distribution for the maximal number of failures derived from a resource provider’s observations. The hybrid model shows that one can increase or decrease the granularity of the model in accordance to needs. One can reduce the estimate of the $P(S^*=1)$ by making a rougher, more conservative, estimate of the more unlikely events of $(M+1, N)$ node failures. The authors note that M is an estimate which is dependent on the history of the nodes being used and can be calibrated to “a few” or to “many” nodes.

Erio Castagnoli and Gino Favero (“From benchmarks to generalised expectations”) are concerned with the case of the possibility of considering random variables as sets (hypo- or epigraphs), instead of mere functions which allows to treat random variables in the language and with the tools of measure theory, instead of the commonly adopted functional analysis. They show that, when looking at a random variable as a set, the concepts of the expectation and the expected utility (either “classical” or of the Choquet type) turn out to be slight variations of the same procedure of measuring a set (the truncated hypo- or epigraph corresponding to the given random variable) by means of a product measure (or capacity). They propose to extend this line of reasoning by using a generic (“non-product”) measure or capacity to evaluate the set under examination, thus obtaining a broader concept of an expectation that includes dependence of the utility function on the state (or dependence of the probability on the amount). Basically, they justify the

argument that the expectation of a random variable equals its own certainty equivalent, thus pointing out the equivalence between any random variable and a corresponding degenerate one. They also recover two different ways for defining the associative property of a generalized expectation.

Roy Cerqueti and Giulia Rotundo (“Memory property in heterogeneously populated markets”) deal with the long memory of prices and returns of an asset traded on a financial market. They consider a microeconomic model of the market, and prove theoretical conditions on the parameters of the model that give rise to long memory. In particular, the long memory property is detected in an aggregation framework of agents under some distributional hypotheses on the market’s parameters.

Giulianella Coletti and Barbara Vantaggi (“From comparative degrees of belief to conditional measures”) are concerned with the “best” definition of conditional model for plausibility functions and its subclass of possibility functions. They propose to use the framework of the theory of measurements by studying the comparative structure underlying different conditional models. This approach gives an estimate of the “goodness” and “effectiveness” of the model by pointing out the rules necessarily accepted by the user. Moreover, the results obtained by the authors that are related to the characterization of comparative degree of belief by means of conditional uncertainty measures are shown to be useful in decision theory. It is shown that they are in fact necessary when we need a model for a decision maker taking simultaneously into account different scenarios.

Salvador Cruz Rambaud and María José Muñoz Torrecillas (“Delay and interval effects with subadditive discounting functions”) consider delay effect that appears as an anomaly of the traditional discounted utility model according to which a decrease of the discount rate is performed as waiting time increases. Since in this description it is not clear if the benchmark or the discounted amount availability is fixed or variable, and hence some authors use the terms like common difference effect, immediacy effect, interval effect, etc., the authors try to clarify the concepts of delay and interval effect and deduce some relationships between these concepts and certain subadditive discounting functions.

Bice Cavallo, Livia D’Apuzzo and Gabriella Marcarelli (“Pairwise comparison matrices: some issue on consistency and a new consistency index”) consider multicriteria decision making with the pairwise comparisons of alternatives as an useful starting point for determining the ranking on the set of alternatives. The authors consider consistency conditions of the pairwise comparison matrix that allows to determine a weighted ranking that perfectly represents the expressed preferences. With reference to the new general unifying context proposed, the authors provide some results on a consistent matrix and a new measure of consistency that is easier to compute. Moreover, they provide an algorithm to check the consistency of a pairwise comparison matrix and an algorithm to build consistent matrices.

Fabio Baione, Paolo De Angelis and Riccardo Ottaviani (“On a decision model for a life insurance company rating”) consider a rating system which is meant as a decision support tool for analysts, regulators and stakeholders in order to evaluate capital requirements of a firm under risky conditions. The authors define an

actuarial model to measure the economic capital of a life insurance company basing the model on option pricing theory. In order to assess a life insurance company economic capital, they involve coherent risk measures already used in the assessment of banking Solvency Capital Requirements, according to Basel II standards. The authors show some results obtained by the application of the actuarial model to a portfolio of surrenderable participating policies with minimum return guaranteed and option to annuitize.

Didier Dubois and H  l  ne Fargier (“Qualitative bipolar decision rules: toward more expressive settings”) reconsider their previous approach to multicriteria decision-making whose idea is to choose between alternatives based on an analysis of the pros and cons, i.e. positive or negative arguments with various degrees of strength. Arguments correspond to criteria or affects of various levels of importance and ranging on a very crude value scale containing only three elements: good, neutral or bad. The basic decision rule considered in this setting is based on two ideas: focusing on the most important affects, and when comparing the merits of two alternatives considering that an argument against one alternative can be counted as an argument in favor of the other. It relies on a bipolar extension of comparative possibility ordering. Lexicographic refinements of this crude decision rule turn out to be cognitively plausible, and to generalize a well-known choice heuristics. It can also be viewed in terms of the cumulative prospect theory. The paper indicates several lines of future research, especially an alternative to the bicapacity approach to bipolar decision-making that subsumes both the cumulative prospect theory and our qualitative bipolar choice rule. Moreover, an extension of the latter to non-Boolean arguments is outlined.

Mario Fedrizzi, Michele Fedrizzi, Ricardo Alberto Marques Pereira and Matteo Brunelli (“The dynamics of consensus in group decision making: investigating the pairwise interactions between fuzzy preferences”) present an overview of the soft consensus model in group decision making and investigate the dynamical patterns generated by the fundamental pairwise preference interactions on which the model is based. The dynamical mechanism of the soft consensus model discussed is driven by the minimization of a cost function combining a collective measure of dissensus with an individual mechanism of opinion changing aversion. The dissensus measure plays a key role in the model and induces a network of pairwise interactions between the individual preferences. The collective measure of dissensus is based on nonlinear scaling functions of the linguistic quantifier type and expresses the degree to which most of the decision makers disagree with respect to their preferences regarding the most relevant alternatives. In the extended formulation of the soft consensus model the extra degrees of freedom associated with the triangular fuzzy preferences, combined with non linear nature of the pairwise preference interactions, generate various interesting and suggestive dynamical patterns which are discussed.

J  nos Fodor (“Fuzzy preference relations based on differences”) introduces quaternary fuzzy relations in order to describe difference structures. He develops and discusses three models which are based on three different interpretations of an implication. Moreover, the author determines functional forms of the quaternary relation by solutions of functional equations of the same type.

Cesarino Bertini, Gianfranco Gambarelli and Angelo Uristani (“Indices of collusion among judges and an anti-collusion average”) propose two indices of collusion among judges of objects or events in the context of subjective evaluation, and an average based on these indices. Their work may be viewed to have different aims, notably to serve as a reference point for appeals against the results of voting already undertaken, to improve the quality of scores summarized for awards by eliminating those that are less certain, and, indirectly, to provide an incentive for reliable evaluations. The authors present a computational algorithm and point out possible applications of their technique in various fields, from economics to finance, insurance, arts, artistic sports, etc.

José Luis García-Lapresta, Bonifacio Llamazares and Teresa Peña (“Scoring rules and consensus”) consider that voters rank order a set of alternatives and a scoring rule is used for obtaining a set of winning alternatives using the scoring rule that is not previously fixed, but analyzing how to select one of them in such a way that the collective utility be maximized. In order to generate that collective utility, the authors ask voters for additional information in that agents declare which alternatives are good and their degree of optimism. With that information and a satisfaction function, for each scoring rule they generate individual utility functions such that the utility an alternative has for a voter should depend on whether this alternative is a winner for that scoring rule and on the position this alternative has in the individual ranking. Taking into account all these individual utilities, the authors aggregate them by means of an OWA operator and generate a collective utility for each scoring rule. By maximizing the collective utility, we obtain the set of scoring rules that maximizes consensus among the voters. Then, applying one of these scoring rules a collective weak order on the set of alternatives is obtained, that is, a set of winning alternatives.

Salvatore Greco, Benedetto Matarazzo and Roman Słowiński (“Dominance-based rough set approach to interactive evolutionary multiobjective optimization”) present an application of the dominance-based rough set approach (DRSA) to interactive evolutionary multiobjective optimization (EMO). The preference information elicited by the decision maker in successive iterations consists in sorting some solutions of the current population as “good” or “bad”, or in comparing some pairs of solutions. The “if ... then ...” decision rules are then induced from this preference information using the dominance-based rough set approach (DRSA). The rules are used within EMO to focus on populations of solutions satisfying the preferences of the decision maker. This makes possible to speed up convergence to the most preferred region of the Pareto front. The resulting interactive solution schemes, corresponding to the two types of preference information, are called DRSA-EMO and DRSA-EMO-PCT, respectively. Within the same methodology, the authors propose the DARWIN and DARWIN-PCT methods make it possible to take into account robustness issues in multiobjective optimization.

Janusz Kacprzyk and Sławomir Zadrozny (“Supporting consensus reaching processes under fuzzy preferences and a fuzzy majority via linguistic summaries”) consider the classic approach to the evaluation of degrees of consensus due to Kacprzyk and Fedrizzi in which a soft degree of consensus is a degree to which, for instance, “most of the important individuals agree as to almost all of the rele-

vant options”. The fuzzy majority, expressed as fuzzy linguistic quantifiers (most, almost all, ...) is handled via Zadeh's classic calculus of linguistically quantified propositions and Yager's OWA (ordered weighted average) operators. The soft degree of consensus is used for supporting the running of a moderated consensus reaching process along the lines of Fedrizzi, Kacprzyk and Zadrożny. Linguistic data summaries, in particular in its protoform based version proposed by Kacprzyk and Zadrożny are employed to indicate in a human consistent way some interesting relations between individuals and options to help the moderator identify crucial (pairs of) individuals and/options with whom/which there are difficulties with respect to consensus. An extension using ontologies representing both knowledge on the consensus reaching process and domain of the decision problem is discussed

Gabriella Marcarelli and Viviana Ventre (“Decision making in social actions”) consider decision making in social action that involves both individual optimal choices and social choices. The theory of “perverse effects” by Boudon shows that the sum of rational individual choices can produce a very undesirable global effect. Then, decision making in social action must take into account the theory of cooperative games with many players in order to obtain the optimal strategies. Because of the semantic uncertainty in the definition of social actions, it is preferable assume that the issues are represented by fuzzy numbers. This is the basic idea proposed by the authors.

Antonio Maturo, Massimo Squillante and Aldo G.S. Ventre (“Coherence for fuzzy measures and applications to decision making”) consider coherence, which is a central issue in probability, in a class of measures that are decomposable with respect to Archimedean t -conorms, in order to interpret the lack of coherence. Coherent fuzzy measures are utilized for the aggregations of scores in multiperson and multiobjective decision making. Furthermore, a geometrical representation of fuzzy and probabilistic uncertainty is considered in the framework of join spaces and, more generally, algebraic hyperstructures. The consider extensions of the coherence principle in nonadditive settings, exemplified by ambiguous or fuzzy settings, that is relevant for non-additive models in decision making, e. g., non-expected utility models.

Paola Modesti (“Measures for firms value in random scenarios”) proposes a set of axioms in order to characterize appropriate measures of the (random) value of a company which provides a (sublinear) valuation functional consistent with the existence of a financial market. It makes it possible to give an upper and a lower bound to the value of a firm. The author considers also, in a random context, some classical valuation methods and test them with respect to the axioms.

Hannu Nurmi (“Thin rationality and representation of preferences with implications to spatial voting models”) is concerned with some aspects of thin rationality that is of a primary concern in the current micro economic theory and formal political science. This concept refers to the behavioral principle stating that rational people act according to their preferences. Provided that the individual's preference is a binary, connected and transitive relation over alternative courses of action, one can define a utility function that represents the individual's preferences so that when acting rationally – i.e. in accordance with his/her preferences – he or she

acts as if maximizing his/her utility. In the case of risky alternatives, i.e. probability mixtures of certain outcomes, a similar representation theorem states that the individual's preferences can be represented as a utility function with an expected utility property. These utility functions assign risky prospects utility values than coincide with weighted sums of the utility values of those outcomes that may materialize in the prospect. The weights, in turn, are identical with the probabilities of the corresponding outcomes. The author discusses also spatial models in which the individuals are identified as their ideal points in a space, and similarly the decision alternatives are represented as points in the space. The author approaches the spatial voting games from the angle of aggregation paradoxes, notably those of Ostrogski, Simpson, the exam paradox, etc..

C.M. Sarris and A.N. Proto ("Quantum dynamics of non-commutative algebras: the $SU(2)$ case") discuss the application of the maximum entropy formalism (MEP) which makes it possible to find the dynamics of Hamiltonians associated with non commutative Lie algebras. For the $SU(2)$ case, it is easy to show that the Generalized Uncertainty Principle (GUP) is an invariant of motion. The temporal evolution of the system is confined to Bloch spheres whose radius lay on the interval $(0;1)$. The GUP defines the fuzziness of these spheres inside domain for the $SU(2)$ Lie algebra.

Rita A. Ribeiro, Tiago C. Pais and Luis F. Simões ("Benefits of full-reinforcement operators for spacecraft target landing") discuss the benefits of using full reinforcement operators for site selection in spacecraft landing on planets. Specifically, the authors discuss a modified uninorm operator for evaluating sites and a fimica operator to aggregate pixels for constructing regions that will act as sites to be selected at lower spacecraft altitude. An illustrative case study of spacecraft target landing is presented to clarify the details and usefulness of the proposed operators.

Giulia Rotundo ("Neural networks for non-independent lotteries") shows the density of the set von Neumann – Morgenstern utility functions on the set of utility functions that can represent arbitrarily well a given continuous but not independent preference relation over monetary lotteries. The main result obtained by the author is that without independence it is possible to approximate utility functions over monetary lotteries by the von Neumann – Morgenstern ones with arbitrary precision. The approach used is a constructive one. Neural networks are used because of their approximation properties in order to get the result, and their functional form provides both the von Neumann – Morgenstern representation and the necessary change of variables over the set of lotteries.

Romano Scozzafava ("Weak implication and fuzzy inclusion") defines a weak implication (H weakly implies E under P) through the relation $P(E|H)=1$, where P is a (coherent) conditional probability. In particular (as a by-product) the author obtains "inferential rules" that correspond to those of default logic, and discusses also connections between the weak implication and the fuzzy inclusion.

M. Socorro García-Cascales, M. Teresa Lamata and José Luís Verdegay ("The TOPSIS method and its application to linguistic variables") modify the known TOPSIS model to allow for the same linguistic values as the input and output of the process. The proposed method is applied to the process of quality assessment

and accreditation of the industrial engineering schools within the Spanish university system.

Ronald R. Yager (“Information fusion with the power average operator”) deals with the concept of a power average that provides an aggregation operator which allows argument values to support each other in the aggregation process, and describes the properties of this operator. Some formulations for the support function used in the power average are described. The author extends the facility of empowerment to a wider class of mean operators such as the OWA and generalized mean.

We wish to thank, first of all, all the authors for their excellent contributions and a great collaboration in this editorial project. Moreover, we wish to appreciate input and suggestion from the participants at long and inspiring discussions at TRENTO – 2009 The 5th International Workshop on Preferences and Decisions held in Trento, Italy on April 6 – 8, 2009 where the idea of publishing this volume has been conceived and then thoroughly discussed among the participants.

We wish to thanks Dr. Thomas Ditzinger and Ms. Heather King from Springer for their multifaceted support and help in the editorial process of this volume.

June 2010

Salvatore Greco
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