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PLANNING BASED ON DECISION THEORY

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PREFACE

This volume contains papers read at the 6th workshop on " Planning based on Decision Theory", Udine (Italy), Sept. 26-28, 2002 and prepared for final publication.

As its preceding ones, this workshop took place under the auspices of the International School for the Synthesis of Expert Knowledge (ISSEK) and held in the impressive Palazzo del Torso of the Centre International des Sciences Mécaniques (CISM), Udine.

The workshop was organised jointly by Prof. G. Della Riccia (University of Udine), Prof. D. Dubois (University of Toulouse), Prof. R. Kruse (University of Magdeburg), and Prof. H .- J. Lenz (Free University Berlin). As the workshop was an invitational therefore there was no need for a call for contributed papers. Instead of a CfP the organisers recruited research workers who have had an impact on the main topic of the meeting.

Planning is an area that deals with sequential decision problems. Starting from an initial state, we are interested in finding a sequence of actions in order to achieve a set of predefined goals. Planning goes back to the early 60's with the General Problem Solver, which was the first automated planner published in the literature. Typically, this type of planner assumes a deterministic world that can be handled by unconditional, ever successful actions. Despite its limitations it had a strong impact on follow-up research in Artificial Intelligence. On the contrary Dynamic Programming and Markov Decision Theory, developed in connection with Operational Research consider multi-stage decision making under uncertainty with actions depending on the current state reached. It is of interest to note that Bayesian Belief Network and Influence Diagram Methods have their roots in Dynamic Programming. In recent years, Artificial Intelligence research has focused on planning under uncertainty, bringing the two traditions together, with a stress on partially observable states where successive actions are conditioned on the agent knowledge about the current state. Until now, planning methods were successfully applied in production, logistics, marketing, finance, management, and used in robots, software agents, etc.

In recent years, decision analysis has become again an important technique in business, industry and government. This fact is true due to the strongly increasing influence of communication and co-operation over the Internet. Information is expected to be available in real time, at every site, and disseminated to the right person irrespective of end-user devices, cf. UDDI, SOAP, etc.
Decision analysis provides a rational methodology for decision-making in the face of uncertainty. It enables a decision maker to choose among several alternatives in an optimal fashion, taking chances and risks into the account of the value (utility) of

further information to reduce uncertainty. Decision theory gives a concise framework for making decisions based on models. Its components are a state space forming the range of a set of variables, alternatives or potential actions, and constraints on the decision space a set of consequences of actions, and a preference functional encoding an optimality criterion, involving the costs and value of extra information.

It is evident from above that planning of actions based on decision theory is a hot topic for many disciplines. Seemingly unlimited computing power, networking, integration and collaboration have meanwhile attracted the attention of fields like Machine Learning, Operational Research, Management Science and Computer Science. Software agents of e-commerce, mediators of Information Retrieval Systems and Information Systems are typical new application areas.

Section 1 "Decision Theory.

D. Dubois and Hélène Fargier start on "Qualitative Decision Rules Under Uncertainty". They present more than a survey of qualitative decision theory focused on the discussion of the available decision rules under uncertainty, and their properties. It is shown that the emerging uncertainty theory in qualitative settings is possibility theory rather than probability theory. However these approaches lead to criteria that are sometimes either little decisive due to incomparability, or too adventurous because focusing on the most plausible states, or yet lacking discrimination because or the coarseness of the value scale. Some suggestions to overcome these defects are pointed out.
E. Hüllermeier on "Sequential Decision-Making in Heuristic Search" develops a new approach to case-based decision making within the framework of possibility theory. It leads to a decision-theoretic set-up, which combines the cognitive concepts of belief, preference and similarity. The author focuses on the application of this approach to heuristic search and search-based planning. His main idea is to utilise combinatorial optimisation problems already solved in order to improve future search-based problem solving.
P. Miranda, M. Grabisch and P. Gil apply k-additive measures to decision theory in their paper on "Identification of non-additive measures from sample data". They start from some axiomatic results for general fuzzy measures, and add a further axiom to restrict the fuzzy measure to k-additivity. If data is at hand, different algorithms are proposed to calculate the measure that best fits to the data.
The last paper in this section authored by M. Schaal and H.- J. Lenz is on "Notification Planning with Developing Information States". It is concerned with revision of plans for route guidance due to unpredictable events, which happen while being in action. Intelligent notification keeps track of human users plans and events to be expected in the future. As the information states of the notification system vary in time, best choices for intelligent notification do as well. In order to employ the knowledge about future

information states, timed decision trees are enriched with an explicit notion of time-dependent information states and the impact on notification planning is shown.

Section 2 "Planning, Control and Learning"

P. Traverso deals with incomplete knowledge at planning time and partial observability at execution time in his paper on "The Problem of Planning with Three Sources of Uncertainty". His approach is based on "Planning as Model Checking". A planner called "Model Based Planner" (MB) was built. The author presents some recent results in planning in non-deterministic domains, with partial information available at run time, and for requirements expressed in temporal logic.

In their contribution on "Understanding Control Strategies", I. Bratko and D. Suc explain how a given controller like a crane works and achieves a goal. This corresponds to two settings in which the problems 'Reverse Engineering' and 'Behavioural Cloning' arises. The underlying methodology is qualitative tree learning from numerical data and based on a learning program called QUIN.

In their paper on "Local Sructure Learning in Graphical Models", C. Borgelt and R. Kruse study local structure learning that is based on a decision graph representation of the parameter tables. They explore different schemes to select the conditional distributions to merge and examine the behaviour of evaluation measures. Additionally, they present experimental results on standard test cases, which provide some insight into the interdependence of local and global structure learning.

Section 3 "Application of Planning and Decision Making Theory"

In his paper on " Coordination of the Supply Chain as a Distributed Decision Making Problem", C. Schneeweiss considers the impact of symmetric or asymmetric information and of team / non-team behaviour in supply chain management. As most influential aspects he identifies on a medium-term basis contract models based on co-operative game theory and, on a short-term basis, auctions based on principal agent theory. The impact of an integrated view on the whole supply chain is stressed.

H. Rommelfanger is concerned with fuzzy probabilities and utilities in his paper entitled: " Fuzzy Decision Theory - Intelligent ways for solving real-world decision problems and for saving information costs". He uses fuzzy intervals of the ε–λ–type. These special fuzzy sets allow to model vague data in a more flexible way than standard trapezoids. Moreover, the arithmetic operations can be efficiently computed on such imprecise quantities. Various preference orderings on fuzzy intervals are discussed. Based on these definitions the principle of Bernoulli is extended to decision models with fuzzy outcomes. Additional information can be used to improve the prior probabilities.

Moreover, fuzzy probabilities can be used combined with crisp or with fuzzy utilities. New algorithms for calculating the fuzzy expected values are introduced. The author votes for collecting additional information in order to identify a best alternative, however, fairly balanced under cost-benefit considerations.

G. Bamberg and G. Dorfleitner close Section 3 with their paper on "Capital Allocation Under Regret and Kataoka Criteria. They analyse the allocation of a given initial capital between a risk-free and a risky alternative, which means to invest into the stock market or a stock market index. The optimal fraction to invest into the stock market under an expected utility goal has no closed-formula solution. However, the optimal fraction according to the Kataoka regret criterion allows an explicit formula. If studied in the Black/Scholes world, i.e. normally distributed log returns, the allocation problem can be characterised as follows: Under realistic parameter values a_* *increases with the length of the planning horizon.*

The editors of this volume thank very much all our authors for submitting their papers in time, and Mrs. Angelika Wnuk, Free University Berlin, for her dedicated, diligent secretarial work for the workshop.

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- *The International School for the Synthesis of Expert Knowledge (ISSEK) again for promoting the workshop.*
- *The University of Udine for administrative support.*
- *The Centre International des Sciences Mécaniques (CISM) for hosting a group of enthusiastic decision makers and planners..*

On behalf of all participants we express our deep gratitude to FONDAZIONE CASSA di RISPARMIO di UDINE e PORDENONE for their financial support.

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May, 2003

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