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Abstracts of Recent PhDs

Collective Iterative Allocation

Candidate: Christian Guttmann
Department and University: Faculty of Information Technology, Faculty of Medicine, Nursing and Health Sciences, Monash University, Australia
Supervisor: Prof. Dr. Michael Georgeff
Year awarded: 2008
URL: http://www.csse.monash.edu.au/~xtg/

Abstract:

This thesis addresses the problem of collective, iterative allocation which is a challenging problem in the research area of distributed problem solving. We call this problem the Collective Iterative Allocation (CIA) problem. A CIA problem involves a group of agents that endeavours to allocate a team to a task in such a way that it maximises a measure of task performance. A central issue in a CIA problem is that the performance of each team is not known accurately by any agent. However, we assume that each agent has certain reasoning and modelling abilities, for example, each agent can estimate how well each team can perform a task, each agent can communicate its estimations, and each agent can update its estimations if it acquires new information of the performance of teams. CIA problems are experienced in many organisational endeavours such as managing major infrastructure projects as well as in the coordination of large-scale information and communication systems such as enabling collaboration in unmanned vehicle systems or ad-hoc networks.

This thesis studies a unique approach to address the CIA problem. This approach involves the application of a group decision using proposals made by each agent to select a team for a task. These selections are refined over time as the task performance of teams becomes known. We have developed a formal framework and algorithm that captures the main concepts of this approach to the CIA problem.

This thesis offers insights into the influence of theoretical and empirical conditions on the efficiency of the algorithm - measured by solution quality (i.e., the performance of the team for a particular task found by our algorithm) and computational requirement (i.e., the number of assignments required before a solution is found). The theoretical study offers guarantees on optimality aspects and identifies boundaries for the computational requirement. For example, we can guarantee that optimal solutions are found quickly when each agent is optimistic and does not underestimate the teams' task performance. Our empirical study consists of simulation-based experiments that extend on our theoretical insights. These experiments evaluate the role of the mental abilities of agents and the physical ability of teams in the efficiency of the algorithm. The experimental findings show the importance of model accuracy, group decision-making policies, agents' abilities to reason with models, the level of uncertainty related to team performance, and strategies employed by individual agents when making proposals.

Travel Time Prediction for the Planning of Mass Transit Companies: a Machine Learning Approach

Candidate: Joao Mendes Moreira
Department and University: Department of Informatics Engineering, Faculty of Engineering, University of Porto, Portugal
Supervisors: Jorge Freire de Sousa and Alipio Mario Jorge
Year awarded: 2008
URL: https://www.fe.up.pt/si/publs_pesquisa.FormView?P_ID=16007

Abstract:

In this thesis we undertook a study in order to know how travel time prediction can be used in mass transit companies for planning purposes. The main focus was on the prediction of travel times for the definition of bus and driver duties. All these studies assume the existence of data on the actual trips, typically obtained from Automatic Vehicle Location (AVL) systems.

We focused on how much we can increase accuracy if we predict travel times as near the date as possible, instead of using the Scheduled Travel Times (STT). The reason for doing this is that, if the increment is important, it is expected to reduce operational costs and/or increase passengers' satisfaction. We used machine learning approaches. However, we started by defining a baseline method (in order to evaluate comparatively the results obtained with more sophisticated methods) and an expert based method using the knowledge we had at the time together with the traffic experts from the STCP company. Then, we tried three different algorithms with reported good results in different problems.

They were: support vector machines, random forests and projection pursuit regression. For each of these algorithms, exhaustive tests were done in order to tune parameters. Other tests were done using the three focusing tasks: example selection, domain values selection and feature selection. Accuracy was improved using these approaches. The next step was to experiment heterogeneous ensemble approaches in order to ameliorate further the results by comparison with the use of just one model. An extensive survey on ensemble methods for regression was undertaken. Several experiments using the dynamic selection approach were executed. Approaches using ensembles have improved results consistently when compared to the use of just one model. The last set of experiments was the comparison of the baseline, the expert based, the best single algorithm (with the respective tuned parameters and focusing tasks), and the ensemble approach, against the use of STT, on various routes. Results gave advantage in terms of accuracy to the ensemble approach.

Hybrid Optimization Techniques for Industrial Production Planning

Candidate: Pandian M. Vasant
Department and University: Graduate Studies Department, University Putra Malaysia
Supervisors: Nader Barsoum, Sabira Khatun and Zulkifly Abbas.
Year awarded: 2008
URL: https://www.morebooks.de/store/gb/book/hybrid-optimization-for-decision-making-in-an-uncertain-environment/isbn/978-3-8443-0338-4

Abstract:

Soft computing has attracted many research scientists, decision makers and practicing researchers in recent years as powerful computational intelligent techniques, for solving unlimited number of complex real-world problems particularly related to research area of optimization. Under the uncertain and turbulence environment, classical and traditional approaches are unable to obtain a complete solution with satisfaction for the real world problems on optimization. Therefore, new global optimization methods are required to handle these issues seriously. One such method is hybrid evolutionary computation, a generic, flexible, robust, and versatile framework for solving complex problems of global optimization and search in real world applications.

In this Ph. D thesis, the main significant contributions are: formulation of a new non-linear membership function using fuzzy approach to capture and describe vagueness in the technological coefficients of constraints in the industrial production planning problems. This non-linear membership function is flexible and convenience to the decision makers in their decision making process. Secondly, a nonlinear objective function in the form of cubic function for fuzzy optimization problems is successfully solved by 15 hybrid and non-hybrid optimization techniques from the area of soft computing and classical approaches. Among the 15 techniques, three outstanding techniques are selected based on the percentage of quality solution. An intelligent performance analysis table is tabulated to the convenience of decision makers and implementers to select the niche optimization techniques to apply in real word problem solving approach particularly related to industrial engineering problems.

Finally, it is concluded that hybrid optimization techniques are robust, less time-consuming, dependable, high quality solutions and an efficient productive tool for solving the non-linear real world problem in an industrial engineering environment. The hybrid line search with genetic algorithms and hybrid line search with simulated annealing techniques developed in this study are user friendly, easy-to-use and can serve as a teaching and research tool, besides being useful for practicing scientist in the area of industrial engineering.

SLAM Algorithm for a Mobile Robot Navigation Oriented to Maximum Uncertainty Zones

Candidate: Fernando A. Auat Cheein
Department and University: Instituto de Automatica, National University of San Juan, Argentina
Supervisors: Prof. Dr. Ricardo Carelli and Prof. Dr. Fernando di Sciascio
Year awarded: 2009
URL: http://lattes.cnpq.br/5979116269273188

Abstract:

This dissertation offers the development tools and implementation of an SLAM algorithm based on a sequential Extended Kalman filter (S-EKF). The SLAM algorithm is implemented on a non-holonomic unicycle mobile robot with a range sensor laser incorporated on it. The SLAM system state is composed by the robot's pose and the features extracted from the environment. The features correspond to lines and corners. Also a secondary map is maintained. This secondary map stores the beginning and ending points associated with the lines - representing walls- extracted from the environment. The secondary map is updated and corrected along with the SLAM system state updating.

The autonomous SLAM strategy is accomplished by the implementation of two navigation strategies based on the information provided by the SLAM algorithm: a local and a global navigation approach. Both strategies use non-reactive controllers in order to perform the navigation process within the mapped environment. The local navigation strategy determines the local maximum uncertainty points from a local reference frame attached to the mobile robot. The maximum uncertainty points are determined by a variable range frontier point's determination, which establishes the unvisited free-space regions of the local environment. The global navigation strategy is based on the determination of global uncertainty points and the robot has to reach a neighborhood of those points by means of a trajectory controller embedded with the SLAM algorithm. Considering that the random variables of the EKF-SLAM system state used are

Gaussian variables, then the probability of any navigable point with respect to a mapped feature of the environment can be calculated by using the Sum of Gaussians concept, avoiding the gridding of the map. Once a maximum uncertainty point is determined, a stable hybrid trajectory controller drives the robot to a neighborhood of such a point.

All the algorithms and mathematical proposals herein are presented with real time experimental results.

Algorithmic and Complexity Aspects of Simple Coalitional Games

Candidate: Haris Aziz
Department and University: Computer Science Department, University of Warwick, UK
Supervisors: Michael S. Paterson and Dennis Leech
Year awarded: 2010
URL: http://wrap.warwick.ac.uk/3113/

Abstract:

Simple coalitional games are a fundamental class of cooperative games and voting games which are used to model coalition formation, resource allocation and decision making in computer science, artificial intelligence and multiagent systems. Although simple coalitional games are well studied in the domain of game theory and social choice, their algorithmic and computational complexity aspects have received less attention till recently. The computational aspects of simple coalitional games are of increased importance as these games are used by computer scientists to model distributed settings. This thesis fits in the wider setting of the interplay between economics and computer science which has led to the development of algorithmic game theory and computational social choice. A unified view of the computational aspects of simple coalitional games is presented here for the first time. Certain complexity results also apply to other coalitional games such as skill games and matching games. The following issues are given special consideration: influence of players, limit and complexity of manipulations in the coalitional games and complexity of resource allocation on networks. The complexity of comparison of influence between players in simple games is characterized. The simple games considered are represented by winning coalitions, minimal winning coalitions, weighted voting games or multiple weighted voting games. A comprehensive classification of weighted voting games which can be solved in polynomial time is presented. An efficient algorithm which uses generating functions and interpolation to compute an integer weight vector for target power indices is proposed. Voting theory, especially the Penrose Square Root Law, is used to investigate the fairness of a real life voting model. Computational complexity of manipulation in social choice protocols can determine whether manipulation is computationally feasible or not. The computational complexity and bounds of manipulation are considered from various angles including control, false-name manipulation and bribery. Moreover, the computational complexity of computing various cooperative game solutions of simple games in different representations is studied. Certain structural results regarding least core payoffs extend to the general monotone cooperative game. The thesis also studies a coalitional game called the spanning connectivity game. It is proved that whereas computing the Banzhaf values and Shapley-Shubik indices of such games is #P-complete, there is a polynomial time combinatorial algorithm to compute the nucleolus. The results have interesting significance for optimal strategies for the wiretapping game which is a noncooperative game defined on a network.

New Tools for Conviviality: Masks, Norms, Ontology, Requirements and Measures Bridging the Conviviality Gap between Policy and Informatics

Candidate: Patrice Caire
Department and University: Computer Science and Communications Department, Luxembourg University, Luxembourg
Supervisor: Prof. Leon van der Torre
Year awarded: 2010
URL: http://wwwen.uni.lu/snt/people/patrice_caire

Abstract:

The notion of conviviality has an intuitive meaning for human society, which is to feel welcome in a community and at ease with its members. We believe it also has particular significance for the design of artificial social systems. Traditionally conviviality has been shown to be useful in human interactions, thus the abundance of artificial social systems is likely to benefit from its application. In this thesis, we explore the possibility of developing the concept of conviviality in artificial systems in depth. We provide a number of tools to help designers of artificial social systems to include conviviality at the onset of their development.

First, we identify what we believe to constitute a promising field of research. Second, we abstract the notion of conviviality. Starting from the philosophical notion proposed by Illich, "individual freedom realized in personal interdependence". Using Taylor's intuition about a conviviality mask, we advance a formalization in terms of interdependence of agents and their goals, and the social norms that determine that interdependence. Third, we operationalize conviviality for the design of artificial social systems. We establish correspondence between software engineering and social science domains. We formalize the interdependence between members of a group with dependence networks, and use the stakeholder-agent concept to provide individual agents' points of view. Fourth, we propose a way to elicit conviviality requirements during the early phase of the development of artificial social systems, using the Tropos agent methodology. Finally, we provide a glimpse of the type of conviviality properties that can be measured in artificial social systems, and thus define the convivial quality of the system. Throughout this thesis we illustrate our arguments with two running examples, one from Second Life, the other from the city of Luxembourg.

Implicit Abstraction Heuristics for Cost-Optimal Planning

Candidate: Michael Katz
Department and University: Faculty of Industrial Engineering & Management, Technion - Israel Institute of Technology
Supervisor: Prof. Carmel Domshlak
Year awarded: 2010
URL: http://ie.technion.ac.il/~mkatz/

Abstract:

State-space search with explicit abstraction heuristics is at the state of the art of cost-optimal planning. These heuristics are inherently limited nonetheless, because the size of the abstract space must be bounded by some, even if very large, constant. Targeting this shortcoming, we introduce the notion of (additive) implicit abstractions, in which the planning task is abstracted by instances of tractable fragments of cost-optimal planning. We then introduce a concrete setting for this framework, called fork-decomposition, that is based on two novel fragments of tractable cost-optimal planning. The induced admissible heuristics are then studied formally and empirically. While our empirical evaluation demonstrates the accuracy of the fork decomposition heuristics, the runtime complexity of computing them poses an obvious tradeoff. Indeed, some of the power of the explicit abstraction heuristics comes from precomputing the heuristic function offline and then determining h(s) for each evaluated state by a very fast lookup in a "database." But implicit abstraction heuristics are, at first glance, a different story: while their calculation time is polynomial, it is far from being fast. To address this problem, we show that the time-per-node complexity bottleneck of the fork-decomposition heuristics can be successfully overcome. We demonstrate that an equivalent of the explicit abstraction notion of a "database" exists for the fork-decomposition abstractions as well, despite their exponential-size abstract spaces. We then verify empirically that heuristic search with the "databased" fork-decomposition heuristics favorably competes with the state of the art of cost-optimal planning.

Of course, as planning is known to be NP-hard even for extremely conservative planning formalisms, no heuristic should be expected to work well in all planning tasks. Thus, additive ensembles of admissible heuristics are used in cost-optimal planning to exploit the individual strengths of numerous admissible heuristics. The same set of heuristics can, however, be composed in infinitely many ways, with the choice of composition directly determining the quality of the resulting heuristic estimate. Continuing our focus on abstraction heuristics, we describe a procedure that takes a deterministic planning problem, a forward-search state, and a set of admissible heuristics, and derives an optimal additive composition of these heuristics with respect to the given state. Most importantly, we show that this procedure is polynomial-time for arbitrary sets of all abstraction heuristics with which we are acquainted, including explicit abstractions such as pattern databases (regular or constrained) or merge-and-shrink, and implicit abstractions such as fork-decomposition or abstractions based on tractable constraint optimization over tree-shaped constraint networks.

Egalitarian Behaviour in Multi Unit Combinatorial Auctions

Candidate: Javier Murillo Espinar
Department and University: eXiT Research Group, University of Girona, Spain
Supervisors: Beatriz López and Dídac Busquets
Year awarded: 2010
URL: http://eia.udg.edu/~jmurillo/

Abstract:

In environments where resources are perishable and the allocation of resources is repeated over time with the same set or a very similar set of agents, recurrent auctions come up. A recurrent auction is a sequence of auctions where the result of one auction can influence the following ones. These kinds of auctions have particular problems, however, when the wealth of the agents is unevenly distributed and resources are perishable. The bidder drop problem appears when many bidder agents decide to leave the market (because they are participating in many auctions and they are always losing); this lowering of the demand produces a decrease in the prices and, consequently, the auctioneer gets less profit and the auction could even collapse. The resource waste problem turns up when not all the resources are sold (which could be a solution to the previous problem) and they lose their value because perishable resources cannot be stored for future sales. Finally, the asymmetric balance of negotiation power occurs when the richest agents gain enough power to set the prices and they set it at the minimum price possible, causing the collapse of the market. The revenue of the auctioneer is then being affected by all these problems.

In this thesis some fair mechanisms are proposed to deal with these problems, so that the revenue of the auctioneer is improved in the long term. In a recurrent auction a fair solution means that at long term, all participants accomplish their goals in the same degree or in the most equal possible degree, independently of their wealth. Concretely this thesis tackles the recurrent multi-unit auctions (Recurrent MUA) and recurrent multi-unit combinatorial auctions (Recurrent MUCA). In a MUA the auctioneer sells several units of a unique resource and the bidders bid for only a unit while in a MUCA the auctioneer sells several resources and several units of each resource and bidders can bid for packages of resources and different quantities for each resource.

We have experimentally shown how the inclusion of fairness incentives to bidders stay in the auction reducing the effect of the bidder drop problem and reducing the effects of resource waste. We have also experimentally shown how the use of reservation prices can be mixed with priorities in order to obtain mechanisms able to maintain the negotiation power of the auctioneer. However there are some dynamic situations where the fair mechanism needs also a method to avoid that rich bidders obtain the resources at a cheaper price. We have called this mechanism control of fair resources. The combination of these three components: priorities, reservation prices and control of rich bidders bring two of the proposed mechanisms to obtain the best performance under all simulated situations.

Finally, the possible manipulations performed by bidders and equilibriums reached by the fair mechanisms have been studied concluding that fair mechanisms work well in domains where bidders are honest. However, in other situations bidders can manipulate in some way the priorities and reservation prices obtaining non desirable equilibriums for the auctioneer.

Leveraging Repeated Games for Solving Complex Multiagent Decision Problems

Candidate: Andriy Burkov
Department and University: Computer Science & Software Engineering Department, Université Laval
Supervisors: Prof. Brahim Chaib-draa (supervisor) and Prof. Mario Marchand (co-supervisor)
Year awarded: 2011
URL: http://www.damas.ift.ulaval.ca/~burkov/

Abstract:

Making good decisions in multiagent environments is a hard problem in the sense that the presence of several decision makers implies conflicts of interests, a lack of coordination, and a multiplicity of possible decisions. If, then, the same decision makers interact continuously through time, they have to decide not only what to do in the present time, but also how their actual decisions may affect the behaviour of the others in the future. Game theory is a mathematical tool that aims to model such interactions as strategic games of multiple players. Therefore, multiagent decision problems are often studied using game theory. In this context, and being restricted to dynamic games, complex multiagent decision problems can be algorithmically approached.

Starting from these considerations, this thesis has produced three contributions. The first is an algorithmic framework for a distributed planning in non-cooperative dynamic games. This is due to the multiplicity of possible plans is a matter of serious complications for any planning approach. In this context, we have proposed a novel approach based on the concept of learning in repeated games. Our approach permits overcoming the aforementioned complications by means of communication between players.

The second contribution is a learning algorithm for repeated game self-play. This algorithm allows players to converge, in an initially unknown repeated game, to a joint behaviour optimal in a certain, well-defined sense, without communication between players.

Finally, the third contribution is a family of algorithms for approximately solving dynamic games, and for extracting equilibrium strategy profiles. This family is based on a method to compute a nonempty subset of approximate subgame-perfect equilibria in repeated games. This method is then extended for approximating all subgame-perfect equilibria in repeated games, allowing thus to solve more complex dynamic games.

Recognition and Usage of Emotive Parameters in Recommender Systems

Candidate: Marko Tkalčič
Institution: University of Ljubljana Faculty of Electrical Engineering
Supervisor: Prof. Dr. Jurij Tasič
Year awarded: 2011
URL: http://slavnik.fe.uni-lj.si/markot/Main/Bibliography

Abstract:

Due to the growing amount of available multimedia content, recommender systems (RS) are gaining popularity as they assist end users in finding relevant content to suit their personal tastes and needs. Today we are still far from having accurate RS outputs, so the research community is working hard with the goal of improving it. Related work was concentrated on (i) identifying parameters that account for large parts of the users variance and/or (ii) the improvement and fine tuning of underlying recommender algorithms. Recently, researchers have started to explore the usage of human factors in recommender systems.

The thesis introduces the usage of emotions and personalities for the improvement of content-based (CB) and collaborative filtering (CF) recommender systems, which has been a largely ignored approach so far. The underlying assumption is that personality and emotional responses account for a large part of the unexplained variance in users' preferences. Thus, the main thesis' hypothesis was that personality and affective parameters improve the performance of recommender systems.

In order to verify the hypothesis a dataset of usage interaction during the consumption of colour images was first built. The main features of the dataset included the five-factor models (FFM) of the subjects' personalities, explicit ratings of the consumed images and video sequences of the subjects' facial expressions during the content consumption. The user models for the CB recommender system were built with several machine learning (ML) techniques. The features were affective labels that described the average emotive responses in the value-arousal-dominance emotion description model. Furthermore, a FFM personality-based user similarity measure (USM) for the CF system was developed. The algorithm for the unobtrusive affective labeling of images used Gabor based features from the video sequences of facial expressions and the kNN ML technique.

The results of the thesis showed that, both the personality-based USM and the affective modeling, significantly improved the performance of the recommender systems. Based on the proposed methodologies, it is feasible to upgrade the state-of-the-art RS in the direction of affective and personality modeling for better recommendation performances.