Research Achievements (Update to 2013)

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General statement

My current research focuses on issues in the intersection of computer science (especially *artificial intelligence*) and economics (especially *microeconomic theory*). Specifically, I am interested in the study of (cooperative and non–cooperative) strategic–interaction situations between rational agents. This includes the design of algorithms for allowing software agents to act optimal when the interaction protocol is given as well as the design of the protocols (commonly said *economic mechanisms*) to induce the agents to act according to a given desirable behavior. My studies require the use of concepts from *game theory*, as well as operationalizing these concepts by means of tools from the *theory of algorithms* and *artificial intelligence* to find efficient algorithms for computing the corresponding solutions. Furthermore, while game theory provides models that are applicable to static scenarios and that do not capture dynamic scenarios, I am also interested on issues in the intersection of game theory and *machine learning*. Finally, I am interested in developing applications embedding algorithms able to deal with strategic–interaction situations

At the very beginning of my scientific research activities I worked on several artificial intelligence topics, including automated planning, decentralized control, and human–computer interaction.

Computational microeconomics

I distinguish my contributions as theoretical contributions and application contributions. The description of the achievements in each field follows.

Theory

Game theory I am interested in the computational study of game theoretic solution concepts in terms of: computational complexity of finding one (or more or an optimal) exact equilibrium, design of approximate solution concepts and study of their complexity, and study of solution concepts appropriate for learning scenarios. I delivered a tutorial on "Equilibrium computation" at AAMAS 2012 and AAAI 2013 conferences. The main achievements follow:

- *Nash equilibrium*: I explored the adoption of local search techniques to compute an exact and approximate Nash equilibrium. In [37, 38], I explored techniques combining local search with support enumeration algorithms, while in [70] I explored techniques combining local search techniques with complementary pivoting algorithms.
- *Bayes–Nash equilibrium*: I extended support–enumeration algorithms for Nash computation to the case of Bayesian games [33].

- *Strong Nash equilibrium*: I proved that the verification problem for Strong Nash equilibrium is polynomial and I provided an algorithm to compute an exact Strong Nash equilibrium with two–agent games [73], I provided algorithms to find Strong Nash equilibria with games with more than two agents [74] , and I proved that finding a Strong Nash equilibrium is smoothed polynomial [72].
- *Extensive–form Nash refinements*: I provided an algorithm to find an exact Extensive–Form Perfect equilibrium with two–agent games [55], and I proved that the verification problem for the Sequential equilibrium (for any number of players) and Quasi–Perfect equilibrium (for two agents) is polynomial [65].
- *Self–confirming equilibria*: I explored the problem of computing, verifying, and enumerating Self–Confirming equilibria in [66, 68].
- *Stochastic games*: I provided an algorithm to compute an exact equilibrium is switching–control two–agent zero–sum polynomial stochastic games and an approximate equilibrium with theoretical guarantee when the game is not polynomial [26].
- *Simulation–based games*: I proposed algorithms to find an approximate Nash and Subgame Perfect equilibrium with extensive–form simulation–based games [69].

Mechanism design I am interested in the design of computationally efficient mechanisms that are truthful or hard to be manipulated. Specifically, my research focuses on: study of allocative externalities (models and computational complexity) and design of monotonic allocation algorithms to approximate the optimal solution, information externalities and design of mechanisms for scenarios with interdependencies, study of mechanisms that are hard to be manipulated. The main achievements follow:

- *Approximation algorithms*: I explored the problem of designing monotonic approximation algorithms for computationally hard allocation function [71].
- *Externalities*: I proposed economic execution–contingent mechanisms to deal with problems with allocative externalities [34] and information externalities [39].
- *Redistribution*: I proposed role–compatible redistribution mechanisms [28].

Learning in strategic settings I am interested both in the study of learning dynamics of learning agents in games and in the study of how learning algorithms affect the properties of economic mechanisms. The main achievements follow:

- *Multi–agent learning*: I provided an algorithm for multi–agent learning speeding up the strategies convergence to the equilibrium in extensive–form games [75].
- *Evolutionary dynamics*: I provided the sequence–form version of replicator dynamics obtaining an exponential reduction w.r.t. the normal form [67].
- *Online learning and mechanism design*: I explored online learning truthful techniques for mechanism design settings [57, 58].

APPLICATIONS

Auctions and negotiations I am interested in the development of algorithms for the selection of ads to be shown to users in advertising settings. This includes sponsored search auctions, mobile advertising, advertising on social networks. I delivered the lecture on "Automatic Negotiations in Electronic Markets" at EASSS 2008, 2009, 2010. The main achievements follow:

- *Bargaining with uncertain information*: I studied algorithms to find equilibrium strategies in bilateral bargaining games with uncertainty information. In [40, 54], I studied uncertainty over the deadlines; in [12, 14, 15], I studied uncertainty over the reservation prices; in [31, 35, 36], I provided an approach to compute equilibrium strategies with generic one–sided uncertainty; in [49] I provided a survey of the main contributions in the field.

- *Bargaining over multiple issues*: I studied efficient techniques to find agreements in bargaining when multiple issues are negotiate [41, 42].
- *Bargaining in markets*: I studied scenarios in which there can be more than two agents in the bargaining situation. More precisely, I studied bilateral bargaining in markets with and without outside option [46, 56, 45] and multilateral bargaining [13].
- *Computational advertising*: I studied sponsored search auctions [71], and variations in federated settings [27, 28, 34, 39]; a survey of economic mechanisms for web search is provided in [29].
- *Energy markets*: I studied algorithms for the winner determination problem of the wholesale energy market [32, 30].
- *Web service markets*: I studied a variation of the Cournot oligopoly for web services [48].

Telecommunication networks I am interested in the development of protocols for mobile users in wireless networks. For instance, I am interested in protocols for the access to the networks and for delay tolerant networks. The main achievements follow:

- *Network access selection*: I studied models and algorithms for characterizing selfish association of users to network access points [16, 78].
- *Cognitive networks*: I studied congestion games for cognitive networks [77].
- *Optimization in WDM networks*: I studied a best–response dynamic approach to approximate the optimal placement of generators on WDM networks [76].

Security I am interested in resource–allocation algorithms for settings with adversaries, such as, for instance, mobile patrolling situations (where the patroller can be a mobile robot or a human guard), camera control for the security of buildings, hybrid settings with static alarms and mobile resources. I am also interested in information security of wireless networks. I delivered the tutorial on "Security games" at AAMAS 2011 and AAAI 2011 conferences. The main achievements follow:

- *Patrolling games*: I studied the problem of using one or more patrollers to secure an environment with arbitrary topology. In [47] I studied the problem of finding Nash equilibria in repeated patrolling, while in [9] an heuristic approach is proposed. In [19], a general model with single patroller is studied, while in [1] a variation to multiple synchronized robots is proposed, in [22, 23] variations based on partial observability are proposed, in [25] the problem of coordinating multiple patrollers is studied. I studied also the problem of finding, when it exists, a determinist patrolling cycle [18]. An efficient approach based on abstractions is explored in [17]. The general framework is described in [20], while in [3] a robotic simulation is implemented and in [24] a web application to find the patrolling strategies is developed. I studied also the problem of patrolling with alarms in [79]. A simple variation of the previous techniques has been applied to the case of moving cameras [2].
- *Localization games*: I studied game theory models and algorithms for improving the robustness of localization techniques by means of wireless anchors [21, 63, 64]

OTHERS

I worked on a number of application–oriented fields in artificial intelligence classified as decentralized control, automated planning, and human–computer interfaces for disabilities. The main achievements follow.

Decentralized control I worked on the development of decentralized control systems using naive optimization approaches based on cooperative negotiations. The general framework is proposed in [8, 44, 50, 52, 51]. Applications to physiological phenomena are described in [6, 4, 5, 11, 7]. An alternative approach based is proposed in [43].

Automated planning I proposed a distributed approach for automated planning in ambient intelligent settings [10] and a software infrastructure based on multi–agent systems technologies [53].

Human–computer interfaces for disabilities I worked on the development of intelligent interfaces for people suffering verbal disabilities [61, 59, 62, 60].

SUMMARY OF PUBLICATION VENUES

I report below the classification of the main venues over which my papers are published and the number of papers for each main venue.

top–ranking venues on artificial intelligence				
area	*international journal*		*international conference*	
broad artificial intelligence	2	AIJ	8	AAAI
			1	UAI
multi–agent systems	2	JAAMAS	19	AAMAS
economics and computation			1	ACM EC
robotics			2	ICRA

second–tier venues on artificial intelligence				
area	*international journal*		*international conference*	
broad artificial intelligence	2	AMAI	1	ISAIM
	1	AIC	1	ECAI
multi–agent systems			10	IAT
artificial intelligence and medicine	1	AIiM		
games			1	CIG

top–ranking venues on other fields			
area	*international journal*		*international conference*
networking	1	IEEE TMOB	
information technologies in biomedicine	1	IEEE TITB	
security	1	IEEE TSDC	

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