This is the third, and already last newsletter of Cassting. Our project will end in April, with our final meeting being a two-day workshop in Eindhoven colocated with ETAPS 2016, the main European conference in theoretical computer science.

Besides preparing this final event and the final review of the project, the coming months will be very busy: we are still developing and refining techniques to get better solutions to our case studies, and especially about the floor-heating system (see page 3), for which a very nice video has recently been uploaded on our website (and we thank the FoCAS team for their help in producing this video).

We are also continuing our work on the development of models and algorithms for designing complex systems. As you will see throughout this newsletter, we focused on games in the Baire space, where not only the state space but also the action space is infinite; we dealt with energy games in which, together with a strict lower bound, an average upper bound on the energy is imposed; we also started exploring the area of evolutionary games, trying to see how this branch of game theory could come into the play in computer-aided verification and programming.

Finally, let me mention that our Danish colleague Kim G. Larsen has been awarded an ERC advanced grant, and that our German colleague Wolfgang Thomas retires at the end of this project. Congratulations and good luck to both of them!

Nicolas Markey
Scientific Coordinator
markey@lsv.fr
Young Researchers Conference “Frontiers of Formal Methods” in Aachen

The Aachen team of Cassting organized a rather special event in February: a three days international conference for young researchers (mainly PhD students) under the title “Frontiers of Formal Methods” (“FFM”). Cassting scientists from Aachen and the other Cassting partners played a prominent role in this meeting. However, the main financial support came from a research training group based in Aachen: “AlgoSyn” (“Algorithmic synthesis of reactive and discrete-continuous systems”). We invited four further research groups to shape the conference, representing different neighbour subjects of Cassting: PUMA (Program and Model Analysis) in München, QuantLA (Quantitative Logics and Automata) in Dresden and Leipzig, SCARE (System Correctness under Adverse Conditions) in Oldenburg, and the Austrian Research Network ARISE (Rigorous System Engineering).

FFM was a lively meeting point for more than 100 young researchers from all over the world. The program consisted of six invited talks, among them a lecture by Jean-François Raskin (Cassting team Brussels) on “Variations on the Stochastic Shortest Path Problem”, the other invited speakers being Moshe Vardi (Houston), Bernd Finkbeiner (Saarbrücken), Azadeh Farzan (Toronto), Eric Bodden (Darmstadt), and Joel Ouaknine (Oxford). But the main part of the program consisted of short communications by young researchers, each with just 12 minutes of exposition, either on ongoing or recent work, or addressing recently published work. The participants, among them several Cassting researchers, were enthusiastic about the meeting and its organization, and indeed the combination of excellent invited talks with many short reports on current research resulted in an event that was fruitful and opened many perspectives, also for the Cassting research.

Playing in the Baire Space: A New Chapter in Games with Complex Objectives

In recent work of the Aachen team, a branch of research on infinite games was started that had been neglected for decades: In the most recent Cassting workshop (Cachan) we proposed an algorithmic approach – and a solution – of infinite games in which not only the plays are of infinite duration, but where in addition the two players in each move have the option to choose among infinitely many actions. Games of this kind arise in hybrid systems and in any scenario where unconstrained numerical values enter.

In our research, we focus on the natural numbers as the “action alphabet”. This case is known in classical game theory (where one speaks of the “Baire space” as the set of all possible plays), but no algorithmic solutions were available in this setting. The Aachen team succeeded in giving a complete solution for parity games specifiable by so-called N-memory automata working in the Baire space: Such games are determined, and the winner has a winning strategy which can again be executed by an N-memory automaton.

Average-energy games

Games with quantitative objectives are a central model in the Cassting project: they can in particular be used to optimize the accumulation of some resources, be it in accumulated value (total payoff) or average value (mean payoff). Energy games are quantitative games in which the aim is not to optimize, but rather to manage the accumulation of resources, in such a way that the amount of resources (typically, energy) always remains within given bounds. They were introduced several years ago by members of the Quasimodo project (an ancestor of Cassting). The Danish, Belgian and French partners of Cassting recently “merged” both approaches, studying games in which the aim is not to optimize, but rather to manage the accumulation of resources, in such a way that the amount of resources (typically, energy) always remains within given bounds. While both constraints (average energy and bounded energy) alone are rather easy to handle (computationally and/or algorithmically), the combination of both is more involved. In particular, it remains open whether it is possible to decide the existence of a strategy enforcing a lower bound on the energy level together with an upper bound on the average energy level. Our paper, published at GandALF’15, has been invited to a special issue of Acta Informatica.

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Wolfgang Thomas - thomas@automata.rwth-aachen.de

Nicolas Markey - markey@lsv.ens-cachan.fr
Using the evolution to design complex adaptive systems

One of the objective of the Cassting project was to apply concepts from classical game theory to analyse and design collective adaptive systems. Components are thus viewed as players, their behaviour is captured by strategies, system runs are plays, and specifications are winning conditions.

In classical game theory, the players are supposed to be intelligent, rational, and selfish. In contrast, evolutionary game theory can be seen as a branch of game theory focusing on the evolution of population of lifeforms in biology, where these hypotheses do not make sense. The focus is rather on the dynamics of strategy change and on convergence phenomena of the naturally induced dynamical system.

Floor Heating Demonstrator

Controller synthesis for hybrid switching systems, like our floor heating case study provided by the company Seluxit, is a complex computational task that calls for novel approaches and techniques. The floor heating problem has been one of the main challenges and drivers of the Cassting project and after two and half years of effort, we are glad to announce that the researchers of the Cassting project came with several novel ideas in order to provide a practically usable strategy synthesis with a fully automatic communication to the actual hardware components of the floor heating system.

In cooperation with Seluxit, we have built a scaled model of the house provided by the company and showed that the tool UPPAAL Stratego (used for the strategy synthesis) can be linked with the actual hardware devices used in the real house in order to provide an automatic control of the valves in the house. Our adaptive, online strategy synthesis algorithm computes repeatedly optimal strategies for the near-future. It employs advanced machine learning techniques in order to handle the enormous size of the state-space.

The results clearly demonstrate that UPPAAL Stratego can control the house considerably better than the bang-bang controller currently used in the real house, as documented on various weather scenarios based on real historical weather data from the Aalborg airport.

In this framework, players do not choose to play a strategy, they are genetically programmed to play a strategy. However, surprisingly, there are strong links between the convergence phenomena occurring in evolutionary game theory and equilibrium concepts from classical game theory. This suggest a new direction of research for analysing collective adaptive systems where the components would be seen as biological entity. The challenge would then be to smartly program the components in order to reach (as quickly as possible) a stable and desired situation suitable for the whole system.

KIM G. LARSEN (AAU) HAS BEEN AWARDED AN ERC ADVANCED GRANT

Kim G. Larsen has received the funding for an innovative proposal concerning how IT of the future can handle complex systems in the real world. His research project, LASSO (Learning, Analysis, SynthesiS and Optimization of Cyber-Physical Systems), will focus on cyber-physical systems.

KIM G. Larsen is the first Danish computer scientist to be awarded the coveted grant, which is the ERC’s highest recognition.

Studying smart houses via total payoff games

One of the case studies of the CASSTING project was the analysis of a block of houses equipped with solar panels and connected to the electrical network. Each household consumes and produces energy, and therefore can buy and sell electricity.

We have used game theory to represent this situation: each household is a player whose actions consist in selling, buying, and consuming energy. After each action, an household wins or lose money, and its objective is to maximise incomes of money.

From a theoretical viewpoint, two types or games correspond to this setting. If one considers that the households have a list of tasks that they want to achieve by the end of the day, we will use «min-cost reachability games», on the other hand, one can use “total-payoff games” when we want to minimise the loss of money on the long run.

We have designed value iteration algorithms to solve each of these games, that is, methods to compute the best values and strategies. We then applied them on the case study, finding good consumption and trading behaviours for the households in different contexts (for example in summer or winter, where the electricity production is different).
CASSTING’S FINAL EVENT

ETAPS
EUROPEAN JOINT CONFERENCES ON
THEORY & PRACTICE OF SOFTWARE

2-3 April - Eindhoven, Netherlands - Workshop

This workshop is the final event of the Cassting project.

It aims to bring together researchers working on topics related (in a large sense) to formal methods for the automatic verification and synthesis of complex systems.

The workshop will be composed of four invited talks, together with contributed talks (presenting either original or already published work).

Topics of interest include: Games for synthesis of complex interactive computational systems, games played on complex and infinite graphs, games with quantitative objectives, game with incomplete information and over dynamic structures, heuristics for efficient game solving.

The workshop will be held as part of the ETAPS’16, on April 2-3 in Eindhoven. The main conferences of ETAPS will take place between April 4 and April 8, 2016.


Some recent publications


Kim G. LARSEN, Marius MIKULICIONIS, Marco MUNIZ, Jiri SRBA, Jakob Haahr TAANKVIST. Online and Compositional Learning of Controllers with Application to Floor Heating. In TACAS’16. Lecture Notes in Computer Science. Springer, April 2016. (To appear)

Check the entire list of our publications at http://www.cassting-project.eu/list-of-publications/