# Research Statement

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My research interests are at the crossroads of automata theory, formal verification, game theory, logic and model-checking. I am interested in the automatic verification of temporal properties in multi-agent games with a strong emphasis on the logical aspects. I have done works on the model-checking of those logics but have recently focused on semantics related problems of these logics. My interests expand to expressiveness, complexity and knowledge-based problems of these extensions.

**Temporal logics for games**

Among the most famous logical formalism for games, we find the alternating time temporal logic [1] ATL. In ATL, one can quantify over a coalition of agents saying that altogether they can ensure the formula. This implicitly and universally re-quantifies the strategies of all the other agents. This feature allows for an easy model-checking algorithm but severely limits ATL expressiveness. To bypass this lack of expressiveness, many extensions of ATL have been developed: SL, $\mathsf{ATL}_{\mathsf{sc}}$, BSIL, IATL... During my PhD, I have mostly focused on one of those extensions: the Strategy Logic [5] SL. My first result [3] on SL closed a question left open in [5]: the model checking of SL[BG] cannot belong to ELEMENTARY.

**Quantitative constraints in multi-agents games**

During my PhD, I have also investigated the addition of quantitative constraints to temporal logics. Our first work on the subject [2] focuses on quantitative aspects of the computation tree logic CTL. One can extend [3] a quantitative versions cSL[BG] of SL[BG] by adding weights to the game and quantitative constraints to SL[BG]. With two or more weights, the logic trivially has an undecidable model checking and is not of much interest. The one-weight version of cSL[BG] admits a periodic property: for any cSL[BG] formula $\phi$, there exists a threshold $\Gamma \in \mathbb{N}$ and a period $\Lambda \in \mathbb{N}$ such that for any configuration $(q, c)$ where $c > \Gamma$, it holds that $(q, c) \models \phi$ if and only if $(q, c + \Lambda) \models \phi$. While this property does not imply decidability, it is already important in itself since it shows some regularity on the satisfaction relation for this logic.

**Semantics problems regarding strategies' history**

I then began investigating semantic issues in SL. My first results were published in [4] and more advanced results are available in my thesis. In SL, strategies can be quantified at a time $t$ and used at a later time $t'$. In this case, SL considers that a strategy $\delta$ must have knowledge of the history between $t$ and $t'$. This semantic choice is a key element to the decidability of SL model-checking. In [4] was proposed a new semantic where the strategy $\delta$ only has knowledge of the history starting from $t'$. This new version is (counter-intuitively) more expressive than SL and admits an undecidable model-checking. In my thesis, I take a deeper look at the complexity results of SL fragments relatively to this new semantic; in particular I highlight a decidable fragment.

**Knowledge related problems in multi-agents games**

Recently, I have obtain results on knowledge problems surrounding SL: given an agent $A$, what knowledge of the other agents' behaviour is necessary in order to build a working strategy for $A$? These results are available in my thesis and will be soon published.

**Perspectives**

Most extensions of ATL are subject to knowledge-based problems: about the goals of other agents, about the histories on which strategies are evaluated, about the other agents strategies... Outlining all these problems and solving the complexity for each one would greatly improve the understanding of multi-agents systems. Ultimately, I want to participate in creating a comprehensive theorical framework for the verification of multi-agent systems.

# References


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