Games where you can play optimally with finite memory

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October 10, 2019

GT ALGA annual meeting 2019

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⚠ Work in progress ⚠

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A sequel to the critically acclaimed blockbuster by Gimbert & Zielonka

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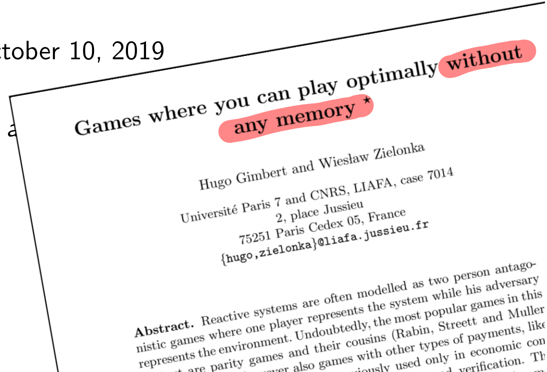
Games where you can play optimally without any memory *

Hugo Gimbert and Wiesław Zielonka

Université Paris 7 and CNRS, LIAFA, case 7014
2, place Jussieu
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{hugo,zielonka}@liafa.jussieu.fr

Abstract. Reactive systems are often modelled as two person antago-
nistic games where one player represents the system while his adversary
represents the environment. Undoubtedly, the most popular games in this
context are parity games and their cousins (Rabin, Streett and Muller

The talk in one slide

Strategy synthesis for two-player turn-based games

Finding **good** controllers for systems interacting with an *antagonistic* environment.

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Two directions for **finite-memory determinacy**:

1. lifting under *objective combination* (with S. Le Roux and A. Pauly, in FSTTCS'18 [LPR18]),
2. complete characterization and *lifting from one-player games* (ongoing work).

1 Memoryless determinacy

2 Finite-memory determinacy and Boolean combinations

3 Characterization and lifting corollary

4 Conclusion

Two-player turn-based zero-sum games on graphs

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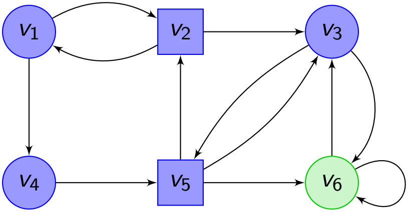
We consider *finite* arenas with vertex *colors* in C. Two players: circle ($\mathcal{P}_1$) and square ($\mathcal{P}_2$). Strategies $C^* \times V_i \to V$.

- ▷ A **winning condition** is a set $W \subseteq C^\omega$.



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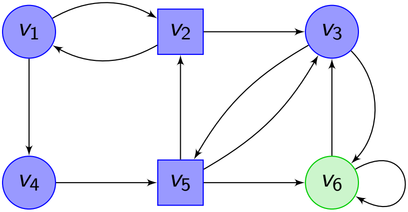

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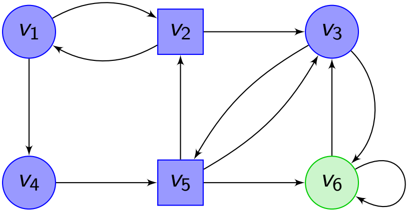

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Memoryless strategies ($V_i \to V$) always suffice for reachability (for both players).

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Virtually always for **simple** winning conditions!

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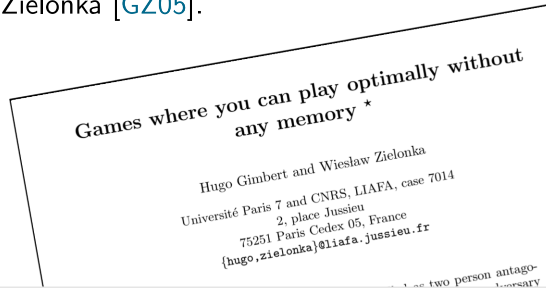
Yes, thanks to Gimbert and Zielonka [GZ05].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Gimbert and Zielonka's characterization

Memoryless strategies suffice for a *preference relation* $\sqsubseteq$ (and the induced winning conditions) **if and only if**

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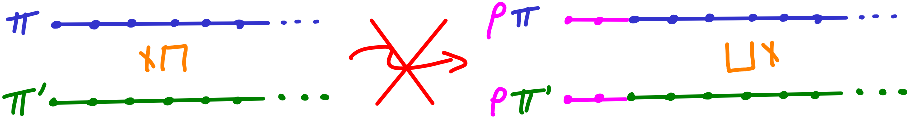

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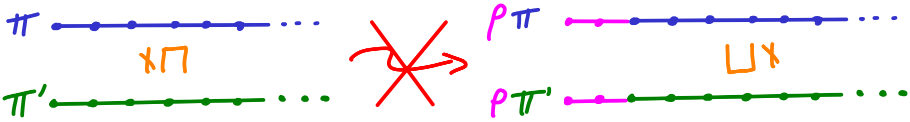

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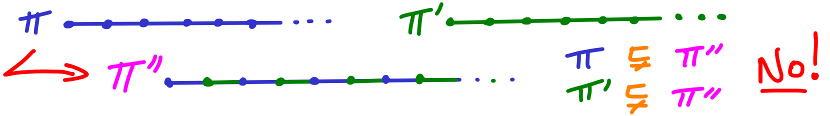

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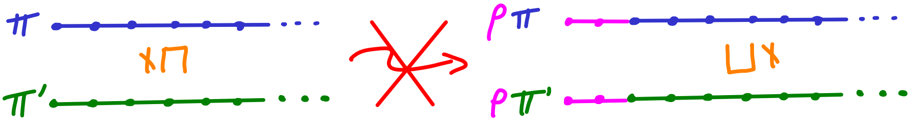

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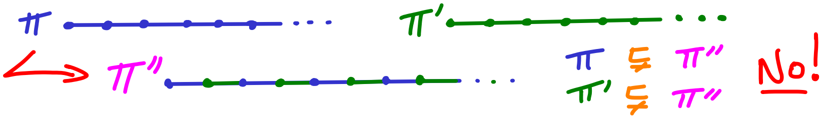

Example: reachability. ⚠ No equivalent for FM ⚠

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then both players have optimal memoryless strategies **in all two-player arenas**.

* Extremely useful in practice! *

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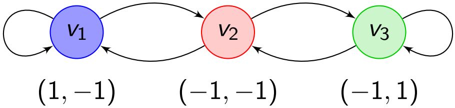

Examples:

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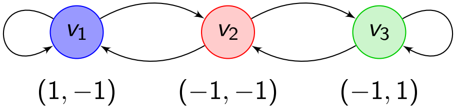

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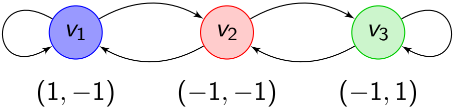

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Two directions:

1. single-objective $\rightsquigarrow$ multi-objective [LPR18],
2. GZ-like characterization and one-player $\rightsquigarrow$ two-player.

With S. Le Roux
& A. Pauly, FSTTCS'18.

Combining winning conditions

Our goal

We want a *general* and *abstract* theorem guaranteeing the sufficiency of finite-memory strategies[a] in games with Boolean combinations of objectives provided that the underlying simple objectives fulfill some criteria.

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Drawbacks:

- concrete memory bounds are huge (as they depend on the most general upper bound).
- sufficient criterion, not full characterization.

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Criterion outline

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$\Longrightarrow$ **Only one exception AFAWK (hSPE vs. opt. strategies).**

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Almost complete picture of the frontiers of FM determinacy for *combinations of objectives* but still **not a complete characterization à la Gimbert and Zielonka.**

1 Memoryless determinacy

2 Finite-memory determinacy and Boolean combinations

3 Characterization and lifting corollary

With P. Bouyer, S. Le Roux, Y. Oualhadj & P. Vandenhove.

ongoing work

4 Conclusion

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Our dream: *exact equivalent* in the finite-memory case.

A partial counter-example (lifting corollary)

Let $C \subseteq \mathbb{Z}$ and the winning condition for $\mathcal{P}_1$ be

$$\overline{TP}(\pi) = \infty \quad \vee \quad \exists^{\infty} i \in \mathbb{N}, \sum_{i=0}^{n} c_i = 0$$

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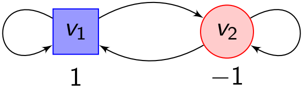

But the two-player one is not!

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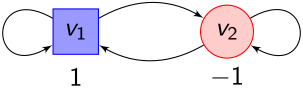

↯ No exact equivalent to GZ ↯

But the two-player one is not!
$\implies \mathcal{P}_1$ needs infinite memory to win.

Hint: non-monotony is a bigger threat in two-player games.
In one-player games, *finite* memory may help.

A new hope

Our goal

GZ-like characterization for finite-memory strategies.

Two tricks:

A new hope

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We obtain a natural GZ-equivalent for FM determinacy, including the lifting corollary (1-p. to 2-p.)!

Still some elements to flesh out.

$\Longrightarrow$ Preprint writing in progress.

Conclusion

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Understand and characterize the frontiers of FM-determinacy.

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Combinations of objectives

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GZ-like criterion

- No exact equivalent.
- Natural criterion and useful lifting corollary.
- With Bouyer, Le Roux, Oualhadj and Vandenhove, ongoing work.

Thank you! Any question?

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