Games on Graphs with a Public Signal Monitoring

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Background

- Multiplayer concurrent games are widely used to model interactions among multiple agents.
- Previous studies mainly assume **perfect monitoring**.
- Under imperfect monitoring, detecting deviations and identifying deviators become difficult.
- This paper studies Nash equilibria under **public signal monitoring**.

Game Model

The paper models games using

$$G = (V, v_{init}, P, Act, \Sigma, Allow, Tab, (\ell_A)_{A \in P}, (payoff_A)_{A \in P})$$

V: Set of vertices (states)

P: Set of players

player A

Act: Set of actions

of player

Σ: Set of public signals

Allow: Available actions

*T*ab: State transition function

ℓA: Signal observed by

payoffA: Payoff function

Each player observes

- public signals
- own actions

instead of the complete game state.

Nash Equilibrium

The objective is to determine whether a Nash equilibrium exists under public signal monitoring.

A strategy profile is a Nash equilibrium if

- every player follows the strategy profile,
- and no player can improve the payoff by changing only their own strategy.

$$payoff_A(out(\sigma)) \geq payoff_A(out(\sigma[A/\sigma'_A]))$$

Example

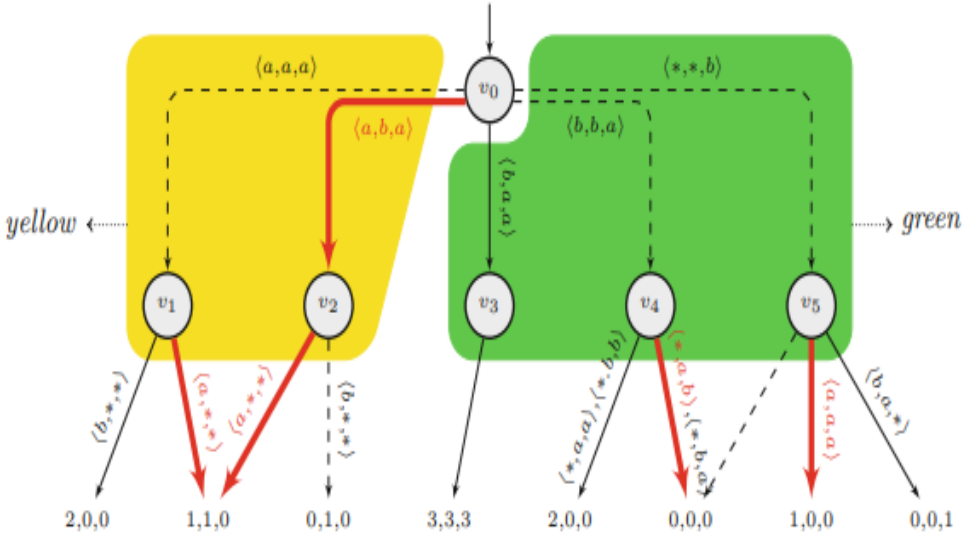

Figure 1 illustrates how public signal monitoring affects players' knowledge.

- All players receive the same public signal.
- Each player knows only their own action.
- Therefore, different players may infer different information from the same observation.
- Detecting the deviating player becomes difficult.

Epistemic Game Abstraction

To solve this problem, the paper introduces

Epistemic Game Abstraction.

The abstraction represents

- players' knowledge,
- possible deviations,

as a two-player turn-based game.

Two-player Game

The Epistemic Game is played by

- Eve, who proposes a strategy profile,
- Adam, who searches for profitable deviations.

If Adam cannot find a profitable deviation,

the strategy corresponds to a Nash equilibrium.

Main Result

The paper proves that

there exists a Nash equilibrium in the original game

if and only if

Eve has a winning strategy in the Epistemic Game.

This result transforms the original problem into solving a two-player game.

Applications

The proposed abstraction is applied to two common payoff objectives.

Boolean ω-regular objectives

- The outcome is evaluated as **Win or Lose**.
- The paper presents an algorithm for deciding the existence of Nash equilibria.

Mean-payoff objectives

- The outcome is evaluated by the **long-term average reward**.
- The paper also provides an algorithm for this objective.

Conclusion

This paper

- formulates multiplayer games with public signal monitoring,
- proposes the Epistemic Game Abstraction,
- proves its correspondence with Nash equilibria,
- and presents algorithms for solving the problem.

Thank you for your attention !