Noncooperative Game Theory: An introduction for engineers

Abstract

In optimization, one attempts to find values for parameters that minimize suitably defined criteria (such as monetary cost, energy consumption, heat generated, etc.) However, in most engineering applications there is always some uncertainty as to how the selected parameters will affect the final objective. One can then pose the problem of how to make sure that the selection will lead to acceptable performance, even in the presence of some degree of *uncertainty*—the unforgiving player that, behind the scenes, conspires to wreck engineering designs. This question is at the heart of many games that appear in engineering applications. In fact, game theory provides a basic mathematical framework for robust design in engineering.

Modern game theory was born in the 1930s, mostly propelled by the work of John von Neumann, and further refined by Morgenstern, Kuhn, Nash, Shapley and others. Throughout most of the 1940s and 1950s, economics was its main application, eventually leading to the 1994 Nobel prize in Economic Science awarded to John Nash, John C. Harsanyi, and Reinhard Selten for their contributions to game theory. It was not until the 1970s that it started to have a significant impact on engineering; and in the late 1980s it led to significant breakthroughs in control theory and robust filtering. Currently, game theory pervades all areas of engineering.

References

[1] J. Hespanha. *Noncooperative Game Theory: An Introduction for Engineers and Computer Scientists*. Princeton Press, June 2017.

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Syllabus

Lecture #1 – Introduction to non-cooperative game

- Introduction to non-cooperative games (slides 1-12, Chapter 1 of [1])
- Applications to engineering design (slides 13-20, Chapter 1 of [1])

Lecture #2 – Zero-sum matrix games

- Security levels and pure policies (slides 21-27, Chapter 3 of [1])
- Mixed policies and Minimax Theorem (slides 28-36, Chapters 4-5 of [1])

Lecture #3 – Nonzero-sum Games

- Bi-matrix games (slides 37-45, Chapter 9 of [1])
- Nash equilibrium (slides 36-50, Chapter 9 of [1])

Lecture #4 – Potential Games

- Classes of potential games (slides 51-63, Chapters 12-13 of [1])
- Congestion and resource allocation games (Sections 13.4, 13.5, 13.6 of [1])
- Computation of Nash equilibria for potential games (slide 64, Sections 13.7-13.8 of [1])

Lecture #5 – Dynamic Games (discrete-time)

- Game dynamics and information structure (Chapter 14)
- Dynamic Programming for 1-player games (Chapter 15)

Lecture #6 – Zero-sum Dynamic Games

- State-feedback zero-sum dynamic games (Chapter 17)
- Linear quadratic games (Chapter 17)