Chapter 5. Application to Warfare: Guerrillas, Police, and Missiles

- Problem of Guerrillas vs Police
- Problem of the Missile Penetration System
- Limitations of Zero-Sum Games as Modeling

Guerrilas

- Suppose there are m guerrillas, n police and two arsenals
  - The guerillas take the arsenal if they are stronger than the police force at the arsenal.
  - Should the guerillas take an arsenal, they win.
  - Winning means gain one point. Loosing means gain no points.
- What should the attack plan of the guerillas be to maximize their win?
- How should the police respond to this plan?

Known Wins and Losses

- The guerrillas can clearly win if $m > n$
- They should attack either arsenal with full force.
- The police always win if $n \geq 2m$
- They should defend each arsenal with force m.

Straffin's Simplification

- Consider the case of 2 guerrillas and 3 police.
- Suppose the arsenals are "East" and "West"
- We could enumerate multiple possible strategies for the guerrillas and the police. On the guerilla side:
  - 2W – 0E
  - 1W – 1E
  - 0W – 2E
- Straffin simplifies by saying the real decision is how to divide the force, not where to send it.
- This does make analysis easier, but we might doubt his insight.

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Sample Model of n=3, m=4

- Not given in book
- I choose to fully enumerate strategies

Police

Guerrillas		4E - 0W	3E - 1W	2E - 2W	1E - 3W	0E - 4W
	3E - 0W	0	0	1	1	1
	2E - 1W	1	0	0	1	1
	1E - 2W	1	1	0	0	1
	0E - 3W	1	1	1	0	0

Sample Model of n=3, m=4

- 0E is dominated by 1E for the police. Why loose an arsenal by not trying?
- Remember, the police are trying to avoid losses

Police

Guerrillas	4E - 0W	3E - 1W	2E - 2W	1E - 3W	0E - 4W
3E - 0W	0	0	1	1	1
2E - 1W	1	0	0	1	1
1E - 2W	1	1	0	0	1
0E - 3W	1	1	1	0	0

- Also 4E dominated by 1E.
- The game begins to unravel

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Further reductions possible

		Police		
		3E - 1W	2E - 2W	1E - 3W
Guerrillas	3E - 0W	0	1	1
	~~2E - 1W~~	~~0~~	~~0~~	~~1~~
	~~1E - 2W~~	~~1~~	~~0~~	~~0~~
	0E - 3W	1	1	0

		Police		
		3E - 1W	~~2E - 2W~~	1E - 3W
Guerrillas	3E - 0W	0	~~1~~	1
	0E - 3W	1	~~1~~	0

		Police	
		3E - 1W	1E - 3W
Guerrillas	3E - 0W	0	1
	0E - 3W	1	0

- Mixed strategy 50%/50% both players
- The value of the game is 0.50

Reflection on the Game

- Straffin is correct with his assumption of mixed strategies.
- Interpreting the strategies, we see that the guerrillas prefer an “all-in” strategy.
- This relates to the assumption of breaking ties in favor of the defender.
- This generalizes to larger force levels. There is no use for the solitary guerrilla.
- These features of the game ultimately stem from the assumptions of perfect knowledge. Do the opponents really know the force levels?

Missile Penetration Problem

- Based on missile defense problems.
- Suppose that there are two countries, Red and Blue.
- Red has four missiles: two missiles have warheads, two missiles are dummies. Red wishes to destroy blue bases.
- Blue has two anti-missiles. Each blue anti-missile can scan two incoming missiles, select one and destroy it.

Eliminating Dominated Strategies

Red

Blue	WWDD	WDWD	WDDW	DWWD	DWDW	DDWW
12	1	1	0	1	0	0
13	0	1	1	1	1	0
14	0	0	1	0	1	0
23	0	0	0	1	1	1
24	0	0	0	0	1	1
34	0	0	0	0	0	1

13 dominates 14

23 dominates 24, 34

dominates dominates dominates

- Dominated strategies give up wins to dominated strategies (its more than counting wins)

Reduced Game Matrix

- Mixed strategy solution 1/3, 1/3, 1/3 for both players

		Red		
		WWDD	WDDW	DDWW
Blue	12	1	0	0
	13	0	1	0
	34	0	0	1

- The basic insight: send the red missiles in volleys, hoping to overwhelm blue defenses

Small Scale Tactics and Zero-Sum Games

- Straffin defends the use of zero-sum games in military tactical planning
- However he acknowledges its limitations in larger-scale strategic questions of war
- Another explanation for Straffin's reservation
    - Some strategic choices in warfare open up entirely new theaters of war.
    - Thus the scale of win and loss is no longer constant
    - Thus, military planners have the capability of choosing tactics which open up a non-zero sum game.

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