Evolutionary Game Theory

Dr. Vimal Kumar, Assistant Professor of Economics

Indian Institute of Technology Kanpur, vimalk@gmail.com

Evolutionary biology

- Idea: genes are the prime determinants of observable characteristics [called fitness] in a given environment.
  - More fit organisms [on average] produce more offspring.
  - Meaning that the genes which provide greater fitness get increased representation in the population.
- The notion of natural selection as the mode of evolution.

Regular vs. Evolutionary Game Theory

Game theory

- Rational players make decisions consciously and strategically.
- Fundamental Question: How does strategic interaction among the players decide the ourcome of a game.

Evolutionary game theory

- Game theoreric concepts continues to apply even if no player is using any reasoning or making conscous decisions
- Fundamental Question: Which behavior will persist in a population?

- Natural selection replaces rational behavior
- Survival of the fittest

Evolutionary game theory

- Key idea: In a population, the success of an organism depends on how it interacts with other organisms.
  - It doesn't make sense to measure fitness of an individual organism
  - So fitness must be evaluated in the context of the full population in which it lives
- Analogous to the game theory that we have learnt
  - Player
  - Strategy
  - Payoff
  - Game Matrix

Beetles of another kind [Chapter 7, Networks, Crowdsand Markets by Easely and Kleinberg]

- Beetle‘s fitness depends on finding and processing food effectively
- If a mutation happens: Beetles with larger body size
  - Let us assume: A large beetle need, on average, more food
- What should be the cons mutation in the beetles’
- Is it so?

The Beetles' world example [Cont]

- A beetle competes with other beetles for food
  - A large beetle would get more food on average in comparison to a small beetles.
- In case of a competition for food between two beetles. Let us assume:
  - If both beetles are of same size, they both get equal shares
  - If a beetle is large and the other is small, the large beetle gets the majority share.
  - A large beetle experiences less fitness in comparison to a small beetle for the same quantity of food

The Beetles' world example [Cont]

- The size game between two beetles

	Small	Large
Small	6,6	1,10
Large	10,1	4,4

- Beetles are not rationally deciding to become large or small. It is hardwired in genes.
- Natural selection works over longer time scale.

Evolutionary stable strategies

- The concept of a Nash equilibrium, as it is, doesn‘t make sense in this setting
  - The reason is that none of the players are deciding their strategies rationally.
- What is needed:
  - A genetically determined characteristics and behavior [strategy] that becomes stable throughout the population
  - Mutations becoming ineffective
- The concept of “*evolutionary stable strategy*”

Evolutionary stable strategy (ESS)

- Incumbents and mutants in the population. ESS is a strategy that cannot be invaded by a mutant population
- In an ESS, mutants have lower fitness (reproductive success) compared with the incumbent population.
- Let us assume that each beatle is repeatedly and randomly paired off with other beetles [No same pair]
- A beetle‘s fitness = Average fitness from food interactions = reproductive success

•A strategy is evolutionarily stable if it cannot be invaded by a mutant strategy.