随机生态与空间演化博弈

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Contents

文献综述

1. 随机生态与空间演化博弈

1.1 弱选择下的空间演化博弈

相关文献链接：Spatial evolutionary games with weak selection, 2017, PNAS.

1.1.1 摘要翻译

进来，一套严格的数学理论来解释弱自然选择机制之下的空间博弈理论。所谓弱自然选择，指的是各种策略的 payoff 差别不大。分析的关键在于，如果合理地重标度时间和空间，那么空间模型就会收敛于某个偏微分方程（PDE）的解。这种方法可以用来分析 2×2 的博弈，但还有一些 3×3 的博弈的 PDE 极限是未知的。本文中，我们给出了一大类 3×3 的博弈的确定行为，并通过模拟验证了规律。总之，空间的效应等价于改变 payoff 矩阵，并且只要这个过程确定，空间博弈的行为可以由 replicator 方程来预测（We say predicted here because in some cases the behavior of the spa- tial game is different from that of the replicator equation for the modified game.）。举个例子，石头剪刀布博弈有一个复制方程，可以旋转出边界。而空间使这个系统稳定了下来，并导出了均衡。

关键词：癌症建模、公共资源博弈、骨癌、石头剪子布。

演化博弈的一般假设为：人口是同质的混合，也就是说，每个人的复制矩阵是相同的。详见（Hofbauer 和 Sigmund）的书。如果 u_i 是选择策略 i 的人的频率，那么我们有

$$\frac{du_i}{dt} = u_i(F_i - \bar{F}), \tag{1.1}$$

$$\text{where } F_i = \sum_j G_{i,j}u_j \tag{1.2}$$

其中 F_i 是每种策略的效用，G_{ij} 是二人博弈时，两人分别选择 i,j 策略时，第一个人得到的 payoff；$\bar{F} = \sum_i u_i F_i$ 是平均效用。

这种同质混合假设对于生态学中的演化博弈或者肿瘤的形成来说，并不适用。所以我们需要理解空间结构是如何影响

1.2 Citation

This statement requires citation [**article_key**]; this one is more specific [**book_key**].

1.3 Lists

Lists are useful to present information in a concise and/or ordered way[1].

1.3.1 Numbered List

1. The first item
2. The second item
3. The third item

1.3.2 Bullet Points

- The first item
- The second item
- The third item

1.3.3 Descriptions and Definitions

Name Description

Word Definition

Comment Elaboration

[1] Footnote example...

2. In-text Elements

2.1 Theorems

This is an example of theorems.

2.1.1 Several equations

This is a theorem consisting of several equations.

Theorem 2.1.1 — Name of the theorem. In $E = \mathbb{R}^n$ all norms are equivalent. It has the properties:

$$\big|\,||\mathbf{x}|| - ||\mathbf{y}||\,\big| \leq ||\mathbf{x} - \mathbf{y}|| \tag{2.1}$$

$$||\sum_{i=1}^{n} \mathbf{x}_i|| \leq \sum_{i=1}^{n} ||\mathbf{x}_i|| \quad \text{where } n \text{ is a finite integer} \tag{2.2}$$

2.1.2 Single Line

This is a theorem consisting of just one line.

Theorem 2.1.2 A set $\mathscr{D}(G)$ in dense in $L^2(G)$, $|\cdot|_0$.

2.2 Definitions

This is an example of a definition. A definition could be mathematical or it could define a concept.

Definition 2.2.1 — Definition name. Given a vector space E, a norm on E is an application, denoted $||\cdot||$, E in $\mathbb{R}^+ = [0, +\infty[$ such that:

$$||\mathbf{x}|| = 0 \;\Rightarrow\; \mathbf{x} = \mathbf{0} \tag{2.3}$$

$$||\lambda \mathbf{x}|| = |\lambda| \cdot ||\mathbf{x}|| \tag{2.4}$$

$$||\mathbf{x} + \mathbf{y}|| \leq ||\mathbf{x}|| + ||\mathbf{y}|| \tag{2.5}$$

2.3 Notations

Notation 2.1. *Given an open subset G of $\mathbb{R}^n$, the set of functions φ are:*

1. *Bounded support G;*
2. *Infinitely differentiable;*

a vector space is denoted by $\mathscr{D}(G)$.

2.4 Remarks

This is an example of a remark.

R The concepts presented here are now in conventional employment in mathematics. Vector spaces are taken over the field $\mathbb{K} = \mathbb{R}$, however, established properties are easily extended to $\mathbb{K} = \mathbb{C}$.

2.5 Corollaries

This is an example of a corollary.

Corollary 2.5.1 — Corollary name. The concepts presented here are now in conventional employment in mathematics. Vector spaces are taken over the field $\mathbb{K} = \mathbb{R}$, however, established properties are easily extended to $\mathbb{K} = \mathbb{C}$.

2.6 Propositions

This is an example of propositions.

2.6.1 Several equations

Proposition 2.6.1 — Proposition name. It has the properties:

$$\big|\,||\mathbf{x}|| - ||\mathbf{y}||\,\big| \leq ||\mathbf{x} - \mathbf{y}|| \tag{2.6}$$

$$||\sum_{i=1}^{n} \mathbf{x}_i|| \leq \sum_{i=1}^{n} ||\mathbf{x}_i|| \quad \text{where } n \text{ is a finite integer} \tag{2.7}$$

2.6.2 Single Line

Proposition 2.6.2 Let $f, g \in L^2(G)$; if $\forall \varphi \in \mathscr{D}(G)$, $(f, \varphi)_0 = (g, \varphi)_0$ then $f = g$.

2.7 Examples

This is an example of examples.

2.7.1 Equation and Text

■ **Example 2.1** Let $G = \{x \in \mathbb{R}^2 : |x| < 3\}$ and denoted by: $x^0 = (1,1)$; consider the function:

$$f(x) = \begin{cases} e^{|x|} & \text{si } |x - x^0| \leq 1/2 \\ 0 & \text{si } |x - x^0| > 1/2 \end{cases} \tag{2.8}$$

The function f has bounded support, we can take $A = \{x \in \mathbb{R}^2 : |x - x^0| \leq 1/2 + \varepsilon\}$ for all $\varepsilon \in]0\,;5/2 - \sqrt{2}[$. ■

2.7.2 Paragraph of Text

■ **Example 2.2 — Example name.** Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi. Morbi auctor lorem non justo. Nam lacus libero, pretium at, lobortis vitae, ultricies et, tellus. Donec aliquet, tortor sed accumsan bibendum, erat ligula aliquet magna, vitae ornare odio metus a mi. Morbi ac orci et nisl hendrerit mollis. Suspendisse ut massa. Cras nec ante. Pellentesque a nulla. Cum sociis natoque penatibus et magnis dis parturient montes, nascetur ridiculus mus. Aliquam tincidunt urna. Nulla ullamcorper vestibulum turpis. Pellentesque cursus luctus mauris.

■

2.8 Exercises

This is an example of an exercise.

Exercise 2.1 This is a good place to ask a question to test learning progress or further cement ideas into students' minds. ■

2.9 Problems

Problem 2.1 What is the average airspeed velocity of an unladen swallow?

2.10 Vocabulary

Define a word to improve a students' vocabulary.

Vocabulary 2.1 — Word. Definition of word.

II

Part Two

3. Presenting Information

3.1 Table

Treatments	Response 1	Response 2
Treatment 1	0.0003262	0.562
Treatment 2	0.0015681	0.910
Treatment 3	0.0009271	0.296

Table 3.1: Table caption

Referencing Table 3.1 in-text automatically.

3.2 Figure

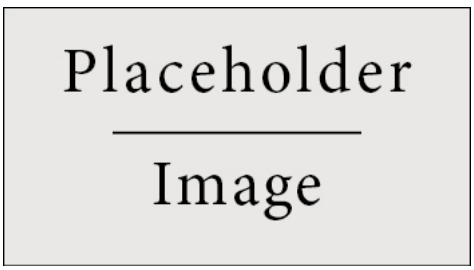

Figure 3.1: Figure caption

Referencing Figure 3.1 in-text automatically.

Bibliography

Articles

Books