Thesis Title

Thesis Subtitle

Author Name

B.Sc. Final Year Dissertation

Cardiff School of Mathematics

Acknowledgments

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

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.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Contents

List of Figures

Chapter 1

Introduction

1.1 Introduction

There is this data that is pretty awesome, I'm going to plot it and show it to you in sections 1.2 and 1.3.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

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.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla. Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetuer.

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

1.2 The data

In Figure 1.1 we see data that was generated using (1.2):

$$x \in \{x \in \mathbb{Z} | 1 \leq x \leq 1999\} \tag{1.1}$$

$$y = 2(1+\epsilon)x + 5 \tag{1.2}$$

where $\epsilon \in (-0.5, 0.5)$ is a random number.

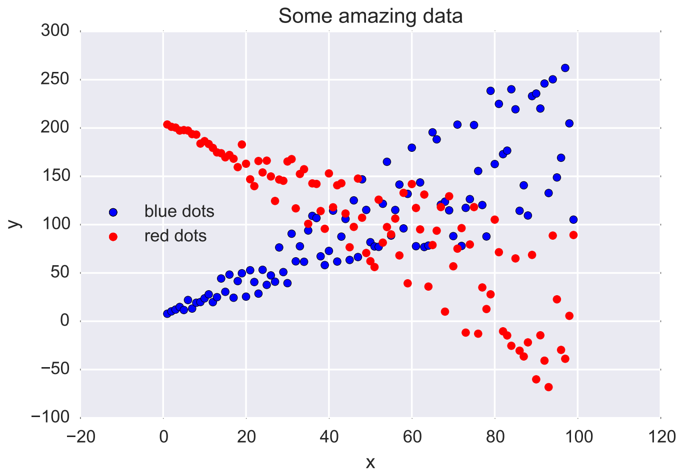

Figure 1.1: The great data

1.3 The distribution of the data

Figure shows the distribution of the data.

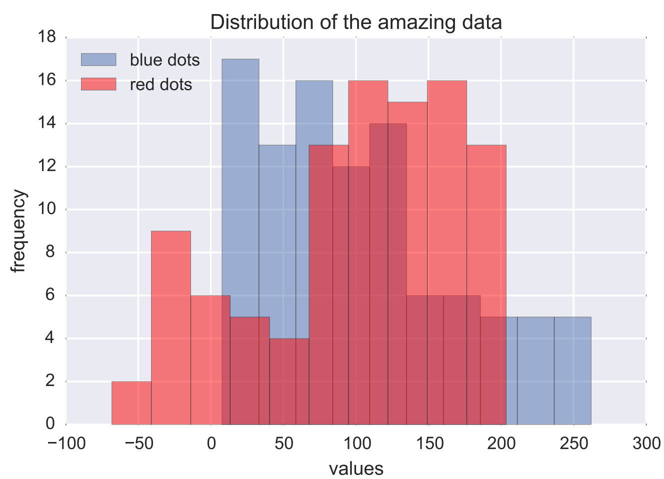

Figure 1.2: The distribution of the great data

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus.

Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

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.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla. Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetuer.

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

1.4 Conclusion

This chapter was amazing, here is a reference to a paper [5].

Chapter 2

Literature Review

2.1 Background

- Explain Prisoner's Dilemma

- Axelrod's original tournament

- Work to reproduce Axelrod's tournament [5]

Year	Reference	Number of Strategies	Type
1979		13	Standard
1979		64	Standard
1984		64	Evolutionary
1991		13	Noisy
2005		223	Varied
2012		13	Standard

is often used to model systems in biology [6], sociology [3], psychology [4], and economics [2].

2.2 Fingerprinting

Definition 1 *If A is a strategy for playing the iterated prisoner's dilemma, then the* ***Joss-Anne of A****, $JA(A, x, y)$ is a transformation of that strategy. Instead of the original behaviour, it makes move C with probablility x, move D with probability y, and otherwise uses the response appropriate to strategy A (if $x + y < 1$).*

The notation JA comes from the initials of the names Joss and Anne. Joss was a strategy submitted to one of Axelrods original tournaments and it would occasionally defect without provocation in the hopes of a slight improvement in score. Anne is the first name of A. Stanley who suggested the addition of random cooperation (refs from ashlock paper) instead of random defection [1]. When $x+y = 1$, the original strategy is not used, and the resulting behavior is a random strategy with probabilities (x, y). In more general terms, a JA strategy is an alteration of a strategy A that causes the strategy to be played with random noise inserted into the responses.

Definition 2 *A **Fingerprint** $F_A(S, x, y)$ with $0 \leq x, y \leq 1$, $x + y \leq 1$ for strategy S and probe A, is the function that returns the expected score of strategy S against $JA(A, x, y)$ for each possible (x, y).*

Definition 3 *The **Double Fingerprint** $F_{AB}(S, x, y)$ with $0 \leq x, y \leq 1$ returns the expected score of strategy S against $JA(A, x, y)$ if $x + y \leq 1$, and $JA(B, 1-y, 1-x)$ if $x + y \geq 1$.*

Definition 4 *Strategy A' is said to be the **Dual** of strategy A if A and A' can be written as finite-state machines that are identical except that their responses are reversed.*

Theorem 1 *If A and A' are dual strategies, then $F_{AA'}(S, x, y)$ is identical to the function $F_A(S, x, y)$ extended over the unit square.*

2.3 Example Fingerprint Construction

There are several steps to constructing the Fingerprint of a strategy a basic familiarity of Markov Chains is required. An outline of the steps is as follows:

1. Build the markov chain for IPD between the strategy and probe strategy.
2. Construct the corresponding transition matrix.
3. Find the steady state distribution.
4. Calculate the overall expected score by taking the dot product of the steady state distribution with the payoff vector given in .
5. Plot the resulting function.

We will now apply this process in order to obtain a fingerprint for the strategy Win-Stay-Lose-Shift (sometimes referred to as Pavlov) when probed by Tit-For-Tat.

Step 1 - Build the markov chain.

Step 2 - Construct the transition matrix.

$$T = \begin{array}{c} \\ (C,C) \\ (C,D) \\ (D,C) \\ (D,D) \end{array} \begin{array}{c} \begin{array}{cccc} (C,C) & (C,D) & (D,C) & (D,D) \end{array} \\ \begin{pmatrix} 1-y & 0 & 0 & x \\ y & 0 & 0 & 1-x \\ 0 & 1-y & x & 0 \\ 0 & y & 1-x & 0 \end{pmatrix} \end{array} \tag{2.1}$$

Step 3 - Find the steady state distribution.

$$\pi = \begin{bmatrix} \frac{x(1-x)}{2y(1-x)+x(1-x)+y(1-y)}, \\ \frac{y(1-x)}{2y(1-x)+x(1-x)+y(1-y)}, \\ \frac{y(1-y)}{2y(1-x)+x(1-x)+y(1-y)}, \\ \frac{y(1-x)}{2y(1-x)+x(1-x)+y(1-y)} \end{bmatrix} \tag{2.2}$$

Step 4 - Calculate the expected score.

$$F = \frac{3x(1-x)+y(1-x)+5y(1-y)}{2y(1-x)+x(1-x)+y(1-y)} \tag{2.3}$$

Step 5 - Plot the resulting function.

	0.0	0.2	0.4	0.6	0.8
	0.0	0.2	0.4	0.6	0.8
0.0	(C, C): (1.00, nan)	(C, C): (0.00, 0.00)	(C, C): (0.00, 0.00)	(C, C): (0.00, 0.00)	(C, C): (0.00, 0.00)
	(C, D): (0.00, nan)	(C, D): (0.36, 0.36)	(C, D): (0.38, 0.38)	(C, D): (0.41, 0.42)	(C, D): (0.45, 0.45)
	(D, C): (0.00, nan)	(D, C): (0.29, 0.29)	(D, C): (0.23, 0.23)	(D, C): (0.18, 0.17)	(D, C): (0.09, 0.09)
	(D, D): (0.00, nan)	(D, D): (0.36, 0.36)	(D, D): (0.39, 0.38)	(D, D): (0.41, 0.42)	(D, D): (0.46, 0.45)
0.2	(C, C): (1.00, 1.00)	(C, C): (0.27, 0.25)	(C, C): (0.14, 0.15)	(C, C): (0.12, 0.12)	(C, C): (0.09, 0.10)
	(C, D): (0.00, 0.00)	(C, D): (0.24, 0.25)	(C, D): (0.31, 0.31)	(C, D): (0.35, 0.35)	(C, D): (0.40, 0.40)
	(D, C): (0.00, 0.00)	(D, C): (0.25, 0.25)	(D, C): (0.24, 0.23)	(D, C): (0.18, 0.18)	(D, C): (0.12, 0.10)
	(D, D): (0.00, 0.00)	(D, D): (0.24, 0.25)	(D, D): (0.31, 0.31)	(D, D): (0.35, 0.35)	(D, D): (0.40, 0.40)
0.4	(C, C): (1.00, 1.00)	(C, C): (0.38, 0.38)	(C, C): (0.22, 0.25)	(C, C): (0.20, 0.20)	(C, C): (0.17, 0.18)
	(C, D): (0.00, 0.00)	(C, D): (0.19, 0.19)	(C, D): (0.26, 0.25)	(C, D): (0.30, 0.30)	(C, D): (0.32, 0.35)
	(D, C): (0.00, 0.00)	(D, C): (0.25, 0.25)	(D, C): (0.27, 0.25)	(D, C): (0.21, 0.20)	(D, C): (0.18, 0.12)
	(D, D): (0.00, 0.00)	(D, D): (0.19, 0.19)	(D, D): (0.26, 0.25)	(D, D): (0.30, 0.30)	(D, D): (0.32, 0.35)
0.6	(C, C): (1.00, 1.00)	(C, C): (0.41, 0.43)	(C, C): (0.29, 0.30)	(C, C): (0.26, 0.25)	(C, C): (0.23, 0.23)
	(C, D): (0.00, 0.00)	(C, D): (0.14, 0.14)	(C, D): (0.20, 0.20)	(C, D): (0.24, 0.25)	(C, D): (0.27, 0.31)
	(D, C): (0.00, 0.00)	(D, C): (0.30, 0.29)	(D, C): (0.31, 0.30)	(D, C): (0.26, 0.25)	(D, C): (0.22, 0.15)
	(D, D): (0.00, 0.00)	(D, D): (0.14, 0.14)	(D, D): (0.20, 0.20)	(D, D): (0.24, 0.25)	(D, D): (0.28, 0.31)
0.8	(C, C): (1.00, 1.00)	(C, C): (0.41, 0.40)	(C, C): (0.35, 0.29)	(C, C): (0.27, 0.25)	(C, C): (0.26, 0.25)
	(C, D): (0.00, 0.00)	(C, D): (0.10, 0.10)	(C, D): (0.16, 0.14)	(C, D): (0.20, 0.19)	(C, D): (0.24, 0.25)
	(D, C): (0.00, 0.00)	(D, C): (0.38, 0.40)	(D, C): (0.33, 0.43)	(D, C): (0.32, 0.38)	(D, C): (0.26, 0.25)
	(D, D): (0.00, 0.00)	(D, D): (0.10, 0.10)	(D, D): (0.16, 0.14)	(D, D): (0.20, 0.19)	(D, D): (0.24, 0.25)

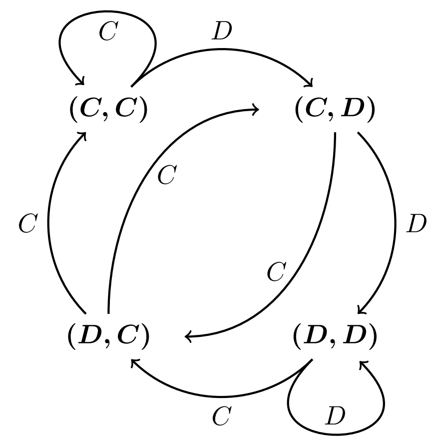

Figure 2.1: FSM for TitForTat

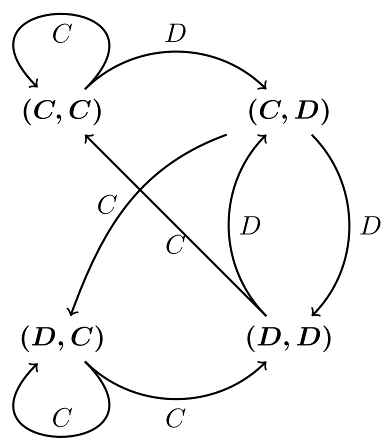

Figure 2.2: FSM for Pavlov (Win-Stay Lose-Shift)

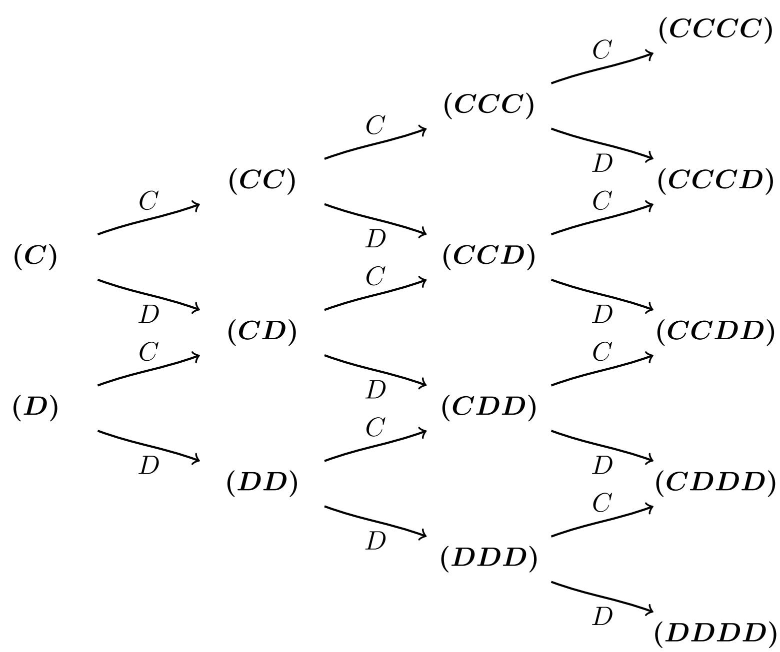

Figure 2.3: FSM for Majority in a game with 4 Turns

Chapter 3

Conclusion

3.1 Introduction

This chapter will just show you a picture drawn in tikz shown in Figure 3.1.

3.2 Conclusion

The end.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

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.

Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit.

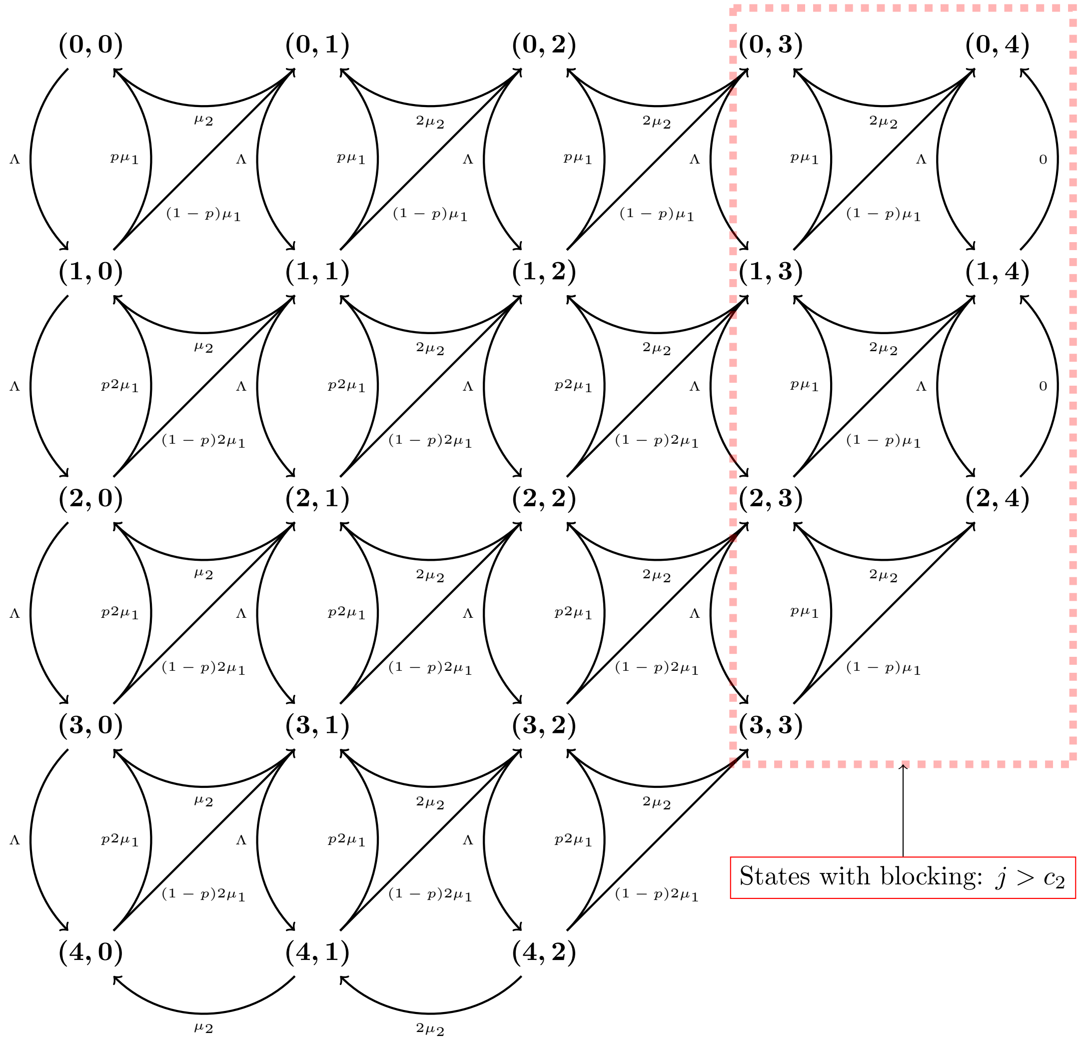

Figure 3.1: A Markov chain

Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

Quisque ullamcorper placerat ipsum. Cras nibh. Morbi vel justo vitae lacus tincidunt ultrices. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In hac habitasse platea dictumst. Integer tempus convallis augue. Etiam facilisis. Nunc elementum fermentum wisi. Aenean placerat. Ut imperdiet, enim sed gravida sollicitudin, felis odio placerat quam, ac pulvinar elit purus eget enim. Nunc vitae tortor. Proin tempus nibh sit amet nisl. Vivamus quis tortor vitae risus porta vehicula.

Fusce mauris. Vestibulum luctus nibh at lectus. Sed bibendum, nulla a faucibus semper, leo velit ultricies tellus, ac venenatis arcu wisi vel nisl. Vestibulum diam. Aliquam pellentesque, augue quis sagittis posuere, turpis lacus congue quam, in hendrerit risus eros eget felis. Maecenas eget erat in sapien mattis porttitor. Vestibulum porttitor. Nulla facilisi. Sed a turpis eu lacus commodo facilisis. Morbi fringilla, wisi in dignissim interdum, justo lectus sagittis dui, et vehicula libero dui cursus dui. Mauris tempor ligula sed lacus. Duis cursus enim ut augue. Cras ac magna. Cras nulla. Nulla egestas. Curabitur a leo. Quisque egestas wisi eget nunc. Nam feugiat lacus vel est. Curabitur consectetuer.

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante. Praesent enim elit, rutrum at, molestie non, nonummy vel, nisl. Ut lectus eros, malesuada sit amet, fermentum eu, sodales cursus, magna. Donec eu purus. Quisque vehicula, urna sed ultricies auctor, pede lorem egestas dui, et convallis elit erat sed nulla. Donec luctus. Curabitur et nunc. Aliquam dolor odio, commodo pretium, ultricies non, pharetra in, velit. Integer arcu est, nonummy in, fermentum faucibus, egestas vel, odio.

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

Bibliography

[1] Daniel Ashlock and Eon Youn Kim. "Fingerprinting: Visualization and automatic analysis of prisoner's dilemma strategies". In: *IEEE Transactions on Evolutionary Computation* 12.5 (2008), pp. 647–659. ISSN: 1089778X. DOI: 10.1109/TEVC.2008.920675 (cit. on p. 9).

[2] Siang Y. Chong and Xin Yao. "Behavioral diversity, choices and noise in the iterated prisoner's dilemma". In: *IEEE Transactions on Evolutionary Computation* 9.6 (2005), pp. 540–551. ISSN: 1089778X. DOI: 10.1109/TEVC.2005.856200 (cit. on p. 9).

[3] N Franken and a P Engelbrecht. "Particle swarm optimization approaches to coevolve strategies for the iterated prisoner's dilemma". In: *Evolutionary Computation, IEEE Transactions on* 9.6 (2005), pp. 562–579. ISSN: 1089-778X. DOI: 10.1109/TEVC.2005.856202 (cit. on p. 9).

[4] Hisao Ishibuchi and Naoki Namikawa. "Evolution of iterated prisoner's dilemma game strategies in structured demes under random pairing in game playing". In: *IEEE Transactions on Evolutionary Computation* 9.6 (2005), pp. 552–561. ISSN: 1089778X. DOI: 10.1109/TEVC.2005.856198 (cit. on p. 9).

[5] Vincent Knight et al. "An Open Framework for the Reproducible Study of the Iterated Prisoner ' s Dilemma". In: *Journal of Open Research Software* 4.1 (2016), e35. DOI: 10.5334/jors.125 (cit. on pp. 8, 9).

[6] Karl Sigmund and Martin A Nowak. "Evolutionary game theory". In: *Current Biology* 9.14 (1999), pp. 503–505. ISSN: 0960-9822. DOI: 10.1007/978-1-4614-1800-9_63 (cit. on p. 9).