

**Automated backgammon player: learning through self-play**

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I hereby declare that this dissertation is all my own work, except as indicated in the text:

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# **Abstract**

Backgammon is one of the oldest board game known which has simple rules and easier strategies to implement. Consequently, it has been implemented in machine learning in decades. On the other hand, Neural Network also is used widely in the modern society, especially in machine learning. Through Artificial Neural Network (ANN) could make machines think like a human and behave like a human.

In this dissertation, I will present, design, and implement a Backgammon self-player in Java using ANN to train a model. This model helps computer learn play backgammon that it could find the optimal solution as far as possible. My aim is to finish a backgammon model with a simplified backgammon game, and then evaluate the model with other similar games online.

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# **Chapter 1 Introduction**

## 1.1 Project Description

The intention of this project is to create an automatic Backgammon player through its self-learning which could provide better interactive intelligent movements. In traditional board games with AI, the programmers set up the rules and provide strategy algorithms with a standard to judge the whole board. Typically, the self-learning player could learn the strategies during the practice and board games so that this method would help machine think like human more.

## 1.1 Background

Backgammon is one of the oldest board game known and many computer scientists implement new techniques using Backgammon as a practice object. This board game not only depends on dice’s results but also needs a global view of whole board rather than each small movement. Due to the simplest rule compared to other board games and easiest implement using algorithms, Backgammon is suitable for beginners to do some mobile phone games and desktop games in the early stage. As a consequence, there is a great amount of development and research on this type of game.

## 1.3 Project Aim & Objectives

The aim of the project:

This project will attempt to replicate a backgammon player that had been developed by Pollack and Blair, successfully using an ANN trained through self-learning, beginning with a simplified version of backgammon, and moving on to a more realistic version of the game.

The main of objectives of the project are as follows:

• Design and implement Backgammon board game in Java and document.

• Do research on the former Backgammon games or ANNs.

• Create an ANN as described as the requirements specification mentioned in project description.

• Fully test the system against other Backgammon games online.

Firstly, I would write a demo in Java to be familiar to backgammon and read related paper on backgammon and ANN. Secondly, according to the optimal doubling written by Keeler and Spencer (1975) and the optimal strategy written by Thorp (1988), apply these strategies on demo. Then the demo should use self-learning and start applied in ANN model. Finally, testify the model and do reflection all the time. In this period, how to evaluate the board is the key point that it must satisfy the strategies noted before. Finish a report contained above mentioned.

**1.4 Motivations**

As mentioned in above, there are some possible use cases using the same method. Two use cases as following:

1. **Game development:**

Regardless of board games or other puzzle games, programmers could implement self-learning to instead of the traditional programming mode that set up engine as AI. In addition, with the continuous progress of its algorithm of the game, it also can help human to cultivate more talented people. On the other hand, it is an opportunity to practice in Machine Learning for beginners.

1. **ANN technological development**

ANN could not only be used in development of games deeply, but also in other social areas. For example, ANN could be used in GPS navigation and always to provide users a better solution in different occasions and improve by self-learning.

## 1.5 Document Content & Scope

As mentioned before, this project will adopt the Waterfall engineering methodology and will thus proceed in a linear fashion. More specifically, the project will proceed with sequential steps, where each step will solve a particular problem in the process. The structure will thus be as follows:

1. **Abstract**: A section for summarizing the goal and result of the project.
2. **Introduction**: introduction of whole project and introduce more related information
   1. **Project Description**: The project description of content of project
   2. **Background**: Introduce Backgammon board game and why I choose this game to implement ANN model to train an automatic Backgammon player
   3. **Project Aim & Objectives**: Give the project development direction and how it implement
   4. **Motivation**: List some possible further implications of this project or what goals could help to achieve
3. **Methodology**: To complete method in efficiency way, it introduces the spheres of technology, ideology and working methodology
   1. **Preliminary Research**: Give examples of some related work and summarize the technology, ideology and working methodology
4. **Requirements & Specifications**: Give more detailed information on this model or what needs to prepare before training.
5. **Feasibility Study**: Analyze the problems based on the suitability of previous technologies.
6. **Neural Network Design**: A section introduce the design of ANN and specific components
   1. **ANN Design**: A high level overview of the whole ANN model design
   2. **Individual design components**: A low level pay attention to how each individual component in the system will work
7. **Implements**: How it implement and analyze the result
8. **Testing**: Test the codes and evaluate this board game with other Backgammon board game
9. **Review**: Reflection on the process and project
10. **Appendices**: Additional information about meeting records, tests and complimentary works completed for this project

# **Chapter 2 Methodology**

## 2.1 Preliminary Research

Firstly, the topic had been discussed and solved by 1990s and different people had various solutions. Mention ANN in Backgammon, Tesauro’ work is one of the most significant that he has published dozens of paper about the Backgammon, especially his TD-Gammon program. Another influenced my work deeply is coevolutionary self-play approach worked by Pollack and Blair. So in the following part, I would introduce more detailed information about their conclusion and controversy.

### 2.1.1 Gerald Tesauro

In 1992, Gerald Tesauro developed a computer backgammon program “TD-Gammon” using artificial neural networks (ANNs). The performance of TD-gammon was at a level not far below that of the best human players of the time, and the strategies explored by TD-gammon led to advances in the theory of backgammon play. In 1998, he also gave the comments on the conclusion worked by Pollack and Blair that he analyzed the differences between two totally different methods and proved the correctness of TD learning nets.

### 2.1.2 Jordan B. Pollack, Alan D. Blair

In 1997, Pollack and Blair demonstrated that a coevolutionary self-play approach to developing backgammon strategies could be successful using ANNs and hill climbing (no reinforcement learning necessary). The result demonstrated that the dynamics of backgammon are particularly suited to coevolutionary learning through self-play (unlike many other games, such as chess) (Pollack, J.B., & Blair, D., 1998). After this paper was published, Tesauro write a short comment to defend his work, arguing that hillclimbing alone is not sufficient to achieve successful learning.

### 2.1.3 Other implements

Recent developments in ANNs (in particular deep learning methods) have generated international headlines through successful game playing implementations such as AlphaGo, capable of beating the best humans. In addition, based on previous professional research on backgammon through self-learning.

**2.2 Summary of Research**

TD-Gammon's exclusive training through self-play rather than tutelage that help computer enable explore strategies itself which had not been considered by human or implemented. The unorthodox strategies had a significant influence on the backgammon that provide compute scientists a

# **Chapter 3 Requirements & Specifications**

## 3.1 Requirements

## 3.2 Specifications

# **Chapter 4 Progress Report**

## 4.1 Progress to date

## 4.2 Planning for the second half of the project cycle

# **Chapter 5 Feasibility Study**

This section is currently under completion and has hence not been included

# **Chapter 6 Neural Network Design**

This section is currently under completion and has hence not been included

# **Chapter 7 Implements**

This section is currently under completion and has hence not been included

# **Chapter 8 Testing**

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# **Chapter 9 Review**

# **Bibliography**

# **Appendices**