# THINKING LIKE HUMAN APPROACH TO AI FOR GAMEPLAYING

Sadika Hasantha Sumanapala

(189398U)

Degree of Master of Science in Artificial Intelligence

Department of Computational Mathematics

University of Moratuwa

Sri Lanka

March 2021

# THINKING LIKE HUMAN APPROACH TO AI FOR GAMEPLAYING

Sadika Hasantha Sumanapala

(189398U)

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Artificial Intelligence

Department of Computational Mathematics

University of Moratuwa

Sri Lanka

March 2021

# Declaration

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Name of the Student:
S. H. Sumanapala

Signature of the Student: Date:

The above candidate has carried out research for the Masters thesis under my supervision.

Name of the supervisor:
Prof. A. S. Karunananda

Signature of the Supervisor: Date:

# Dedication

I dedicate this thesis to my family and friends. I will always appreciate the help of friends for the things all they have done and their valuable thoughts. I dedicate this work and give many thanks to people at University of Moratuwa for their help and especially for lecturers for providing guidance throughout this research.

## Acknowledgement

I would like to express my very great appreciation to Prof. Asoka Karunananda for his generous support for this project.

Also, I would like to thank all the lectures of the Department of Computational Mathematics for their guidance during the course and all the resources and support provided to make this project successful.

# Abstract

Playing games helps humans relax and their minds. Games have a very long history. They were used as a leisure activity even by early humans. It involves both mind and body. With the development of computers games became more complex and entertaining. Computers are extensively used to model, simulate and develop games. Games require us to use our cognitive power to plan and take sudden discussions to win. Chess, Go are highly complex games in terms of options that a player must think about when making a move. There are a lot of different paths that a player can take to win a game. Therefore, many researchers try to use various technologies to develop applications which can play games. The development of these technologies also helps to solve complex problems in completely different areas such as finance, economics, and warfare.

According to the other researchers work. Multi Agent Systems (MAS) have ability to modal complex problems. Because of that we developed a system using MAS to play games. Suggested solutions are developed using thinking of human's behaviors. When humans face a problem, they think about it in several ways. In their mind they compare, contrast and argue to find the best possible solution. Similarly, in multi agent systems intelligent agents solve complex problems by communication, coordination and negotiation. Game playing is a problem solving that involves thinking, decision making and negotiation skills of the human mind. Even though this is very intuitive to the human mind proper designing needs to be done to model this way of problem solving into an AI system. Here we designed a multi agent game playing system to play N-puzzle game. It contains mainly two types of agents: coordinator agent and decision agents. For the N puzzle game there are four decision agents namely up, down, left, right decision agents. They analyze the game state, negotiate with each other to determine the best move to make. For the development of the solution, we used SPADE architecture-based multi agent framework. The results show the proposed solution able to achieve notable improvement (~42%) compared to human players.



**Keywords:** Agents, Multi Agent Systems, Game playing

## Table of Contents


Declaration i

Dedication ii

Acknowledgement iii

Abstract iv

Table of Contents v

List of Figures viii

List of Tables ix

List of Abbreviations x

Chapter 1 Introduction 1

1.1 Prolegomena 1

1.2 About Game Playing and Thinking 1

1.3 Aim and Objectives 2

1.3.1 Aim 2

1.3.2 Objectives 2

1.4 Background and Motivation 3

1.5 Problem in Brief 3

1.6 Structure of the Thesis 3

1.7 Summary 3

Chapter 2 Literature Review 4

2.1 Introduction 4

2.2 Game playing using Artificial Intelligence 4

2.3 Emergence of Multi Agent Systems 5

2.4 Game Playing using Multi Agent Systems 6

2.5 Limitations and Current Approaches 7

2.6 Problem 8

2.7 Summary 8

Chapter 3 Technology Adapted 9

3.1 Introduction 9

3.2 Multi Agent Technology 9

3.2.1 Agent in MAS 9
3.2.2 Communication in MAS 10
3.2.3 Agent modeling software and frameworks 11
3.3 Expert System 12
3.4 Technology of Framework used in Game Player System 12
3.5 Summary 13
Chapter 4 Approach 14
4.1 Introduction 14
4.2 Hypothesis 14
4.3 Input 14
4.4 Output 14
4.5 Process 14
4.6 Users 15
4.7 Features 16
4.8 Summary 16
Chapter 5 Design 17
5.1 Introduction 17
5.2 High Level Architecture 17
5.3 Components of the MAS Game Player System 18
5.3.1 Coordinator Agent 18
5.3.2 Decision Agent 18
5.3.3 Action Agent 19
5.3.4 Communication Layer 20
5.4 Summary 20
Chapter 6 Implementation 21
6.1 Introduction 21
6.2 Tools and Technology 22
6.2.1 Python 22
6.2.2 Redis 22
6.3 Agent Implementation 22
6.3.1 Coordinator Agent 23
6.3.2 Decision Agents 25
6.3.3 Action agent 28
6.4 Communication Layer 28
6.5 Storage Layer 29

6.6 Summary 29

Chapter 7 Evaluation 30

7.1 Introduction 30

7.2 Experimental Design 30
7.2.1 N-Puzzle Game 30
7.2.2 Human player 32
7.2.4 A* N-Puzzle Solver 32
7.2.5 N-Puzzle for MAS Game Player 32
7.3 The Setup 33

7.4 Evaluation Strategy 33
7.4.1 Heuristics 34
7.4.2 Utility of a board state 34

7.5 Experimental Sample Data 35
7.5.1 Collecting data from human players 35
7.5.2 Collecting data from A* n-puzzle solver 35

7.6 Experimental Results 37

7.7 Discussion on Results 38

7.8 Summary 38

Chapter 8 Conclusion & Further Work 40

8.1 Introduction 40

8.2 Concluding Remarks 40

8.3 Limitations and Future Work 41

8.4 Summary 41

References 42

## List of Figures

Figure 5.1: High level architecture of the multi agent game player system 18
Figure 5.2: Design of Decision Agent 19
Figure 5.3: Design of action agent 20
Figure 6.1: Interaction between agents, communication layer and storage 21
Figure 6.2: Pseudo code of an agent program 23
Figure 6.3: Design of coordinator agent 24
Figure 6.4: Request message from coordinator agent 25
Figure 6.5: Decision sequence generation through communication between decision agents 27
Figure 6.6: Decision sequence message 27
Figure 6.7: Agent message format 29
Figure 7.1: 8-Puzzle (Left) and 15-Puzzle (Right) 31
Figure 7.2: 8-Puzzle with an initial configuration (left) and goal configuration (right) 31

## List of Tables

Table 2.1: Summary of the Literature Study 7
Table 7.1: Sample output of game solver 33
Table 7.2: Human player time sheet 35
Table 7.3: A* solver time sheet 36
Table 7.4: Elapsed time to solve the 8-puzzle 36
Table 7.5: Elapsed time to play 8-Puzzle for game player system 37
Table 7.6: Average time to play 8-puzzle for each player system 38

## List of Abbreviations

| | |
|---|---|
| MAS | Multi Agent System |
| API | Application Programing Interface |