DEEP THREE MATCH: SOLVING THE GAME OF THREE MATCH WITH A LEARNED EVALUATION FUNCTION

by

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A proposal submitted to
The University of Birmingham
for the degree of
MASTER OF SCIENCE

School of Computer Science
College of Engineering and Physical Sciences
The University of Birmingham
August 2017

CHAPTER 1

PROPOSAL

1.1 Introduction

In this thesis I will build an artificial intelligent (A.I.) agent which will play and solve the game of three match (think Candy Crush or Bejewelled).

The agent will be composed of a Monte Carlo tree search program, a neural network for the evaluation function, and a neural network for the policy. I will be focussing on the evaluation function and I aim to learn the features of the function using an auto-encoder, then train a neural network which uses these features that can evaluate the game state. I am collaborating with Elliott Davies who will design the policy, and we will both work together to implement the Monte Carlo search.

1.2 Motivation

I am interested in producing a similar program to that of AlphaGo, however, we will apply it to the game of Three Match, not Go. In Three Match the aim of the game is to match three pieces of the same type to break 'ice' underneath and uncover all the 'medals' (refer Figure 1.1). Three Match comes with its own challenges, namely the highly random nature of which type of piece appears on the board. If three cells on the board need to be filled, the program must already consider 20 different potential states. This

Figure 1.1: The authors version of Three Match: Gem Island

in combination with chain reactions of matches, leads to a tremendous branching factor and an enormous search space.

In recent research most A.I. agents still use an evaluation function with hand-selected features, such as AlphaGo. In this thesis we aim to use an auto-encoder and another neural network to learn the features of the function and then determine the optimal weights for the features. This will result in a evaluation function that is learned end-to-end by the program. Learning the entire evaluation function and the stochastic nature of the game make for a challenging project and I am interested to see if the agent can make successful short and long term tactical decisions.

1.3 Plan

In this section I outline the work required to complete this thesis. Each table represents a task, which is broken down into sub-tasks in the description section. A Gantt chart is also included at the end for a graphical view of the project time line.

Task	1. Complete game
Due	2017/06/13
Leader	TB
Collaborator	ED
Objectives	To build a challenging game for an AI agent to solve.
Description	1.1 Make a simple game for proof of concept 1.2 Implement matches for gems 1.3 Implement removable ice 1.4 Implement 'gravity' to pull down gems 1.5 Implement animations 1.6 Implement scoring system 1.7 Implement bonus gems 1.8 Implement combination scoring
Milestones	1.1 Making a simple game 1.6 A fully working game without bonuses
Deliverable	A complete game for the AI to solve

Task	2. Set up game for AI
Due	19/6/2017
Leader	TB
Collaborator	ED
Objectives	To get the game in a state for the AI to control.
Description	2.1 Design the game state representation 2.2 Implement methods to get game state 2.3 Implement methods for AI to call
Milestones	-
Deliverable	A game designed so that an AI can control it.

Task	3. Build naive AI version 1
Due	22/6/2017
Leader	TB
Collaborator	ED
Objectives	Proof of concept for getting an AI to control the game.
Description	3.1 Implement random policy/move selection 3.2 Connect AI to game 3.3 Collate training data from version 1
Milestones	-
Deliverable	A working AI which can control the game.

Task	4. Build naive AI version 2
Due	28/6/2017
Leader	TB
Collaborator	ED
Objectives	Proof of concept for using MCTS, evaluation function, and a policy
Description	4.1 Design sarch, policy, and evaluation function (s, p, e) 4.2 Implement s, p, e 4.3 Collate training data from version 2
Milestones	-
Deliverable	A naive version of the final design of the AI.

Task	5. Gather and collate training data
Due	27/6/2017
Leader	TB
Collaborator	ED
Objectives	To obtain the required training data for the neural networks.
Description	5.1 Set up game to output state to file 5.2 Set up game to distribute to users 5.3 Distrubute game to users
Milestones	-
Deliverable	Game to distribute - 22/06/17 Collated training data 27/07/17

Task	6. Build neural network 1 (NN1) with hand selected features.
Due	4/7/2017
Leader	TB
Collaborator	
Objectives	To build a NN which evaluates the game state
Description	6.1 Design and build NN1 6.2 Train NN1 6.3 Connect NN1 to game
Milestones	-
Deliverable	AI agent with working NN

Task	7. Build neural network 2 (NN2) with learned evaluation function.
Due	14/7/2017
Leader	TB
Collaborator	
Objectives	To build a NN which learns the function features and evaluates the game state.
Description	7.1 Design and build auto-encoder 7.2 Build NN2 with learned features 7.3 Train NN2 7.4 Connect NN1 to game
Milestones	-
Deliverable	AI agent with fully learned evaluation function.

Task	8. Build Monte Carlo tree search program
Due	21/7/2017
Leader	ED
Collaborator	TB
Objectives	To build a tree search program to solve the game.
Description	8.1 Build and design MCTS program 8.2 Connect MCTS program to AI
Milestones	-
Deliverable	A working AI similar in design to AlphaGo

Task	9. Write dissertation
Due	13/8/2017
Leader	ED
Collaborator	TB
Objectives	To write a dissertation.
Description	9.1 Outline of dissertation 26/06/17 9.2 Literature review 21/06/17 9.3 Definition of problem 03/07/17 9.4 Solution to problem 03/07/17 9.5 Why is it novel 03/07/17 9.6 Methodology for NN1 06/07/17 9.7 Half draft 02/07/17 9.8 Full methodology including NN2, search, policy 24/07/17 9.9 Full draft 31/07/17 9.10 Final copy 13/08/17
Milestones	-
Deliverable	Half draft 02/07/17 Full draft 31/07/17

Gantt Chart

Name	Begin date	End date
Literature review draft	05/06/17	06/06/17
Simple working game	05/06/17	10/06/17
Complete game	05/06/17	13/06/17
Implement matches for gems	05/06/17	09/06/17
Implement removeable ice	05/06/17	09/06/17
Implement uncoverable medals	05/06/17	09/06/17
Implement 'gravity' for gems	05/06/17	10/06/17
Implement animations	05/06/17	11/06/17
Implement scoring system	05/06/17	12/06/17
Implement 5 row bonus	12/06/17	13/06/17
Implement T bonus	12/06/17	13/06/17
Implement combo scores	12/06/17	13/06/17
Set up game for AI	14/06/17	19/06/17
Design state representation	14/06/17	15/06/17
Method to get game state	14/06/17	19/06/17
Set up methods for AI to call	14/06/17	19/06/17
Build naive AI version 1	21/06/17	22/06/17
Implement random policy/move selection	21/06/17	22/06/17
Connect AI to game	21/06/17	22/06/17
Collate training data from version 1	21/06/17	22/06/17
Build naive AI version 2	23/06/17	28/06/17
Design search, policy, evaluation (s,p,e)	23/06/17	24/06/17
Implement s,p,e	24/06/17	26/06/17
Connect AI to game	26/06/17	28/06/17
Collate training data from version 2	26/06/17	28/06/17
Gather and collate training data	14/06/17	27/06/17
Set up game to output state to a file	14/06/17	20/06/17
Set up game to distribute to users	14/06/17	20/06/17
Distribute game for gathering data	23/06/17	27/06/17
Build NN1 with hand selected features	27/06/17	04/07/17
Design and build NN1	27/06/17	30/06/17
Train NN1	30/06/17	02/07/17
Connect NN1 to game	03/07/17	04/07/17
Build NN2 which learn full evaluation function	06/07/17	14/07/17
Design and build autoencoder	06/07/17	07/07/17
Build NN2 with learned features	10/07/17	10/07/17
Train NN2	10/07/17	13/07/17
Connect NN2 to game	13/07/17	14/07/17
Build Monte Carlo Search Tree	17/07/17	21/07/17
Design and build MCST	17/07/17	21/07/17
Write proposal	12/06/17	20/06/17
Draft	12/06/17	13/06/17
Final	15/06/17	20/06/17
Write Dissertation	12/06/17	13/08/17
Outline of dissertation	12/06/17	26/06/17
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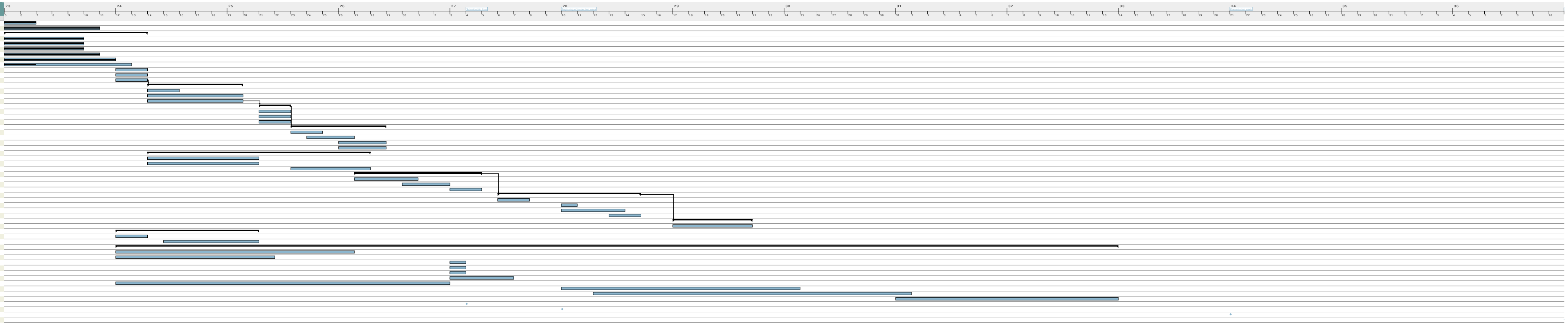
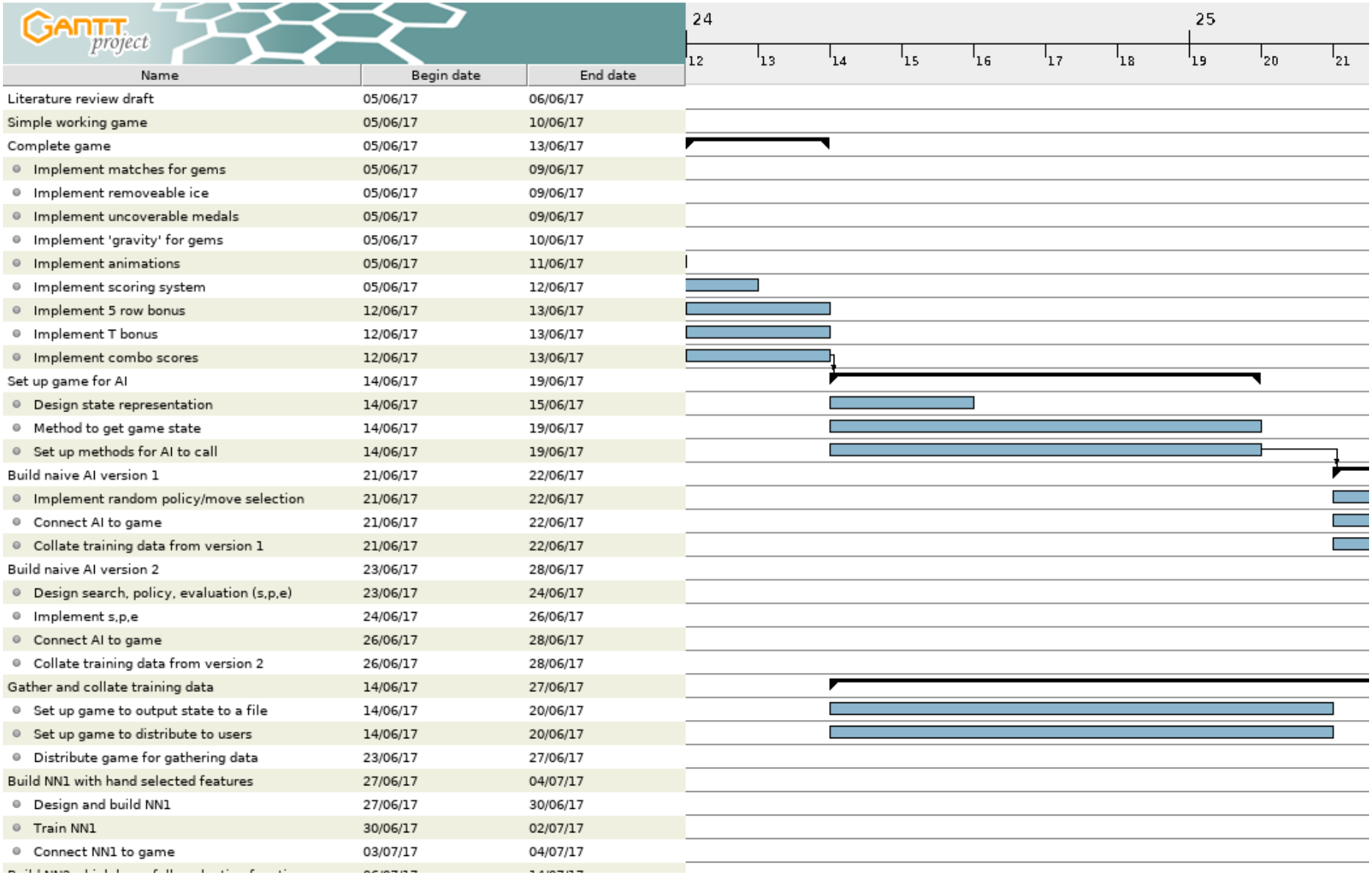
Methodology for NN1	03/07/17	06/07/17
Half draft	12/06/17	02/07/17
Full methodology including NN2, search, policy	10/07/17	24/07/17
Full draft	12/07/17	31/07/17
Final Copy	31/07/17	13/08/17
Submit ethic form	04/07/17	04/07/17
Beginning of inspection week	10/07/17	10/07/17
Presentation week	21/08/17	21/08/17
Deadline for dissertation	11/09/17	11/09/17





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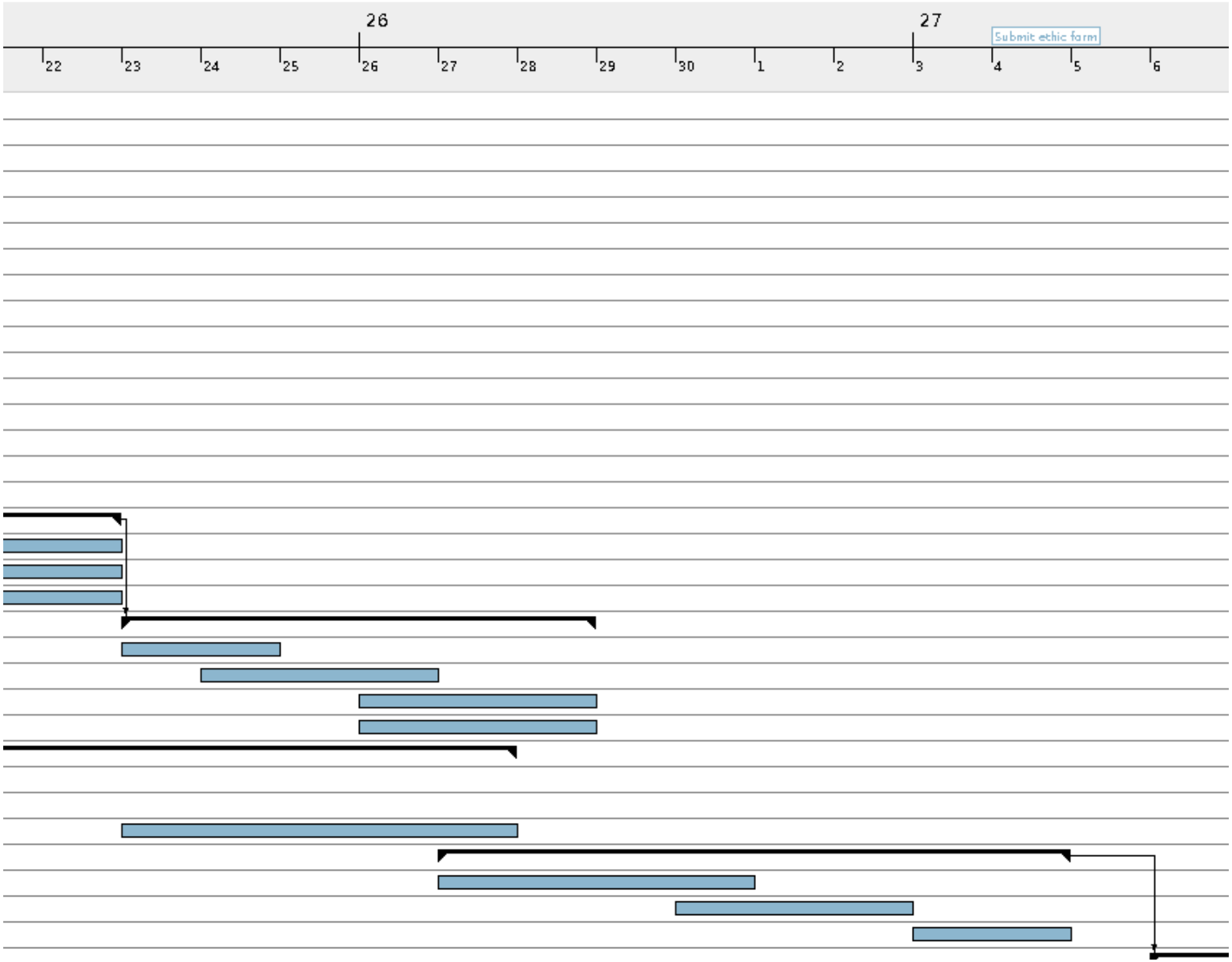
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