**TrojanGo**

## Software Requirement Specification

**Version 1.0 approved**

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**1 . Introduction**

**We are trying to build a Game of Go1 similar to AlphaGo Zero2. Our algorithm should be working for all board sizes but we would be testing for 5\*5, 9\*9, 13\*13 and 19\*19.**

**1.1 TrojanGo Goal**

**What would be different from AlphaGoZero?**

1. **We will be trying with different input features and see how it is behaving.**
2. **Evaluating different neural network design: We will try CNN, ResNet and Inception network for the experiment purpose and record the performance for the comparison.**
3. **Monte Carlo Tree Search : Rather than taking Reward/Penalty as +1/-1 for all game state, can we take the average of value (which MCTS simulation is giving) for the Zt or Zt to be a function of final reward(+1/-1) and average value which we got during the MCTS simulation.**
4. **Evaluating TD(λ)3 algorithm instead of MCTS for the game simulation?**
5. **Training in a distributed environment.**

**1.2 Additional Features**

**Extra Additional Features:**

1. **Our project will have an in-built tool for visualizing the neural network.**
2. **Our bot will be supporting Go-Text-Protocol (GTP) for playing against any open source Go player like GNUGO,Pachi, etc.**

**2 . TrojanGo Domain Knowledge**

**2.1 Big Idea**

**Define all the base classes and functions needed for playing a game of Go. This is like an infra for the entire project to follow and build modules on top of it.**

**Class Agent:**

“”” Agent could be any bot, RandomBot or NeuralNetwork which will be selecting a move and returning it.

“””

bot = RandomBot(Agent)

gamestate = **GameState**.new\_game(BOARD\_SIZE)

gamestate.next\_player = **Player**(Player.black.value) # set player as black

move = bot.**select\_move**(gamestate) # move is a **Move** object and gamestate is a **GameState** object.

gamestate = gamestate.**apply\_move**(move) # **apply\_move** is a **GameState** function

**class GameState:**

def \_\_init\_\_(self, board, next\_player, previous, last\_move):

self.board = board # <1> **Board**

self.next\_player = next\_player # <2> **Player**

self.previous\_state = previous # <3> **GameState**

self.last\_move = last\_move # <4> **Move**

self**.**moves = moves # <5> **int**

# <1> board : What is the current board

# <2> next\_player : Who's going to make the next move.

# <3> previous\_state : What was the previous GameState. Or can be referred to as Parent.

# <4> last\_move : Last move played (Move.point)

# <5> move : Number of moves made in the game so far

**apply\_move**: Now that you have move (say G5 or Point(rows=2, cols=2)) selected (selected by the Agent), you want to apply on the board. So, it will call GoBoard.place\_stone who will take care of placing the stone on the current board. It will also update the total number of moves.

def **apply\_move**(self, move):

“””

Input Params

move : **Move** class.

Return Params

return the new **GameState** object after applying the move.

Internally it will call **Board**.place\_stone.

“””

**new\_game** : To start a new game of Go, call this function.

def **new\_game**(cls, board\_size):

“””

Input : GameState(self), board\_size

Return: new GameState object

“””

**is\_suicide :** Check whether the player’s move is a suicide or not.

A player may not place a stone such that it or its group immediately has no liberties, unless doing so immediately deprives an enemy group of its final liberty. In the latter case, the enemy group is captured, leaving the new stone with at least one liberty

def **is\_suicide**(self, player, move):

“””

Input : GameState(self), Player, Move

Return: bool

“””

**violate\_ko :** Check whether the player’s move is violating KO rule or not. We are checking KO for the last 8 history GameState. If we see the current player’s move is leading to one of the previous board then return ‘True’ meaning it is violating KO rule.

def violate\_ko(self, player, move):

“””

Input : GameState(self), Player, Move

Return: bool

“””

**legal\_moves:** Given the GameState, Return all the legal moves possible. It will internally call whether a given move is a valid move or not (is\_valid\_move) and add all such moves in a list and return it.

def **legal\_moves**(self):

“””

Input : GameState(self)

Return : a list of Move objects.

“””

**is\_valid\_move :** Check whether the given move is valid or not. Internally it will check whether the point is valid or not in terms of board.grid size, whether the move(point) is it’s own eye or is a suicide, whether it is violating KO rule, etc.

**is\_valid\_move**(self, move):

“””

Input : GameState(Self), Move

Return: bool

“””

**update\_total\_moves :** Update the number of moves made so far.

def **update\_total\_moves**(self):

“””

Input: GameState(self)

Return: int

“””

**is\_over :** Check whether the game is over or not. Check for pass, resign or max number of moves played, etc.

def **is\_over**(self):

“””

Input: GameState(self)

Return: bool

“””

**winner** : Declare the winner of the game. Use chinese rules to declare the winner. AlphaGo Zero uses **Tromp–Taylor scoring4** during MCTS simulations and self play training. This is because human scores (Chinese, Japanese or Korean rules) are not well defined if the game terminates before territorial boundaries are resolved. However, all tournament and evaluation games were scored using Chinese rules.

def **winner**(self):

“””

Input: GameState(self)

Return: Player.black or Player.white or draw

“””

class GoBoard:

def \_\_init\_\_(self, board\_width, board\_height, moves = 0):

self.board\_width = board\_width

self.board\_height = board\_width

self.grid = np.zeros((board\_width, board\_width))

self.komi = 0 # <1>

self.verbose = True # <2>

self.max\_move = board\_width \* board\_height \* 2 # <3>

# <1> placeholder of komi, will see it later on how to use

# <2> Keeping for debugging purposes, just a knob for enabling/disabling verbose logs.

# <3> The max moves allowed for a Go game, Games terminate when both players pass or after 19 × 19 × 2 = 722 moves.

copy\_board : Create a deep copy of the board.

def **copy\_board**(self, player, point):

“””

Input : GoBoard(self)

Return: GoBoard

“””

place\_stone : Given Board, Player and Point, place the stone on the current board if the point is valid. **After keeping the stone, remove the dead stones** (take care of how you want to keep liberty for each stone or group of stones, do you want to calculate **liberty** for all on the fly or want to store it after each move and update at later point when it is affected by new move/stone)

If any opposite stones now have zero liberties, remove them.

def **place\_stone**(self, player, point):

“””

Input : GoBoard(self), Player, Point

Return: None

“””

is\_on\_grid : Given Point, check if it is within the board sizes.

def **is\_on\_grid**(self, point):

“””

Input: Point

Return: bool

“””

compare\_board : Given another board, returns true if it is equal to this board.

def **compare\_board(self,board):**

“””

Input : GoBoard(self),GoBoard

Return: bool

“””

display\_board : print the board

def **display\_board**(self):

“””

Input: GoBoard(self)

Return: None

“””

Class Point:

Point(rows, cols)

def neighbors(self): Return all 4 neighbors of the point. These neighbors can be Invalid too (means out of grid), so it is the responsibility of the caller to take care of it.

Class Player:

class Player(enum.Enum):

black = 1

white = 2

def opp(self): return opposition stone color

Class Move:

def \_\_init\_\_(self, point=None, is\_pass=False):

self.point = point

self.is\_play = (self.point is not None)

self.is\_pass = is\_pass

self.is\_selected = False

**play**: Given Point object, this function will return Move object.

@classmethod

def play(cls, point):

return Move(point=point)

**pass\_turn** : It is return Move object with “is\_pass” boolean set to True

@classmethod

def pass\_turn(cls):

return Move(is\_pass=True)

@classmethod

def ply\_selected(cls):

return Move(is\_selected = True)

**GameState**

board: **GoBoard**

next\_player : **Player**

previous\_state : **GameState**

last\_move : **Move**

moves: **int**

Functions:

def apply\_move(self, move)

def new\_game(cls, board\_size)

def is\_suicide(self, player, move)

def violate\_ko(self, player, move)

def legal\_moves(self)

def is\_valid\_move(self, move)

def update\_total\_moves(self)

def is\_over(self)

def winner(self)

**GoBoard**

board\_width: **int** (board\_size)

board\_height: **int** (board\_size)

grid : **numpy.array**(19\*19)

komi : **int**

max\_moves : **int**

Functions:

def copy\_board(self)

def place\_stone(self, player, point)

def is\_on\_grid(self, point)

def compare\_board(self,board)

def display\_board(self)

**Move**

point : **Point**

is\_play : **bool**

is\_pass : **bool**

is\_selected : **bool**

Functions:

def play(point)

def pass\_turn(self)

**Player**

black = 1

white = 2

Functions:

def opp(self):

**Point**

Row: **int**

Col : **int**

Functions:

def neighbors(**self)**

**Fig 2.1 showing the TrojanGo defined Go specific classes and functions.**

**3 . Input Features**

**3.1 Big Idea**

**Build an input feature stack of dimension 17\*19\*19 for the neural network. The input feature stacks can be concatenated in different ways. The two common ways will be …**

**s{t} = [C, X{t=2}, X{t=1}, X{t=0}, Y{t=2}, Y{t=1}, Y{t=0}]**

**s{t} = [C, X{t=2}, Y{t=2}, X{t=1}, Y{t=1}, X{t=}, Y{t=0}]**

**We will be evaluating both the input feature stacks for the performance.**

**<trojangoPlane.py>**

Assuming 5\*5 go board size.

Given: given a board state, generate the input feature stacks/planes (in this case 7\*5\*5)

C = Plane[0] = current player (if Black turn then all ones, if white turn then all zeros)

X{t=2} = Plane[1] = current player all moves made till now, say (i)th move with all ones & others as zeros (self 1st history)

X{t=1} = Plane[2] = current player all moves made till (i-1)th move with all ones & others as zeros (self 2nd history)

X{t=0} = Plane[3] = current player all moves made till (i-2)th move with all ones & others as zeros (self 3rd history)

Y{t=2} = Plane[4] = opposition player all moves made till now (say jth move) with all ones & others as zeros (opp 1st history)

Y{t=1} = Plane[5] = opposition player all moves made till (j-1)th move with all ones & others as zeros (opp 2nd history)

Y{t=0} = Plane[6] = opposition player all moves made till (j-2)th move with all ones & others as zeros (opp 3rd history)

NOTE: if (i-n)th or (j-n)th move doesn't exist then the plane will have all zeros.

AlphaZero: These planes are concatenated together to give input features s{t} = [X{t}, Y{t}, X{t−1}, Y{t−1},..., X{t−7}, Y{t−7}, C].

board\_tensor, s{t} = [C, X{t=2}, X{t=1}, X{t=0}, Y{t=2}, Y{t=1}, Y{t=0}]

**</>**

**4 . Neural Network**

**4.1 Big Idea**

**Evaluating different neural network design: We will try CNN, ResNet and Inception network for the experiment purpose and record the performance for the comparison.**

**5 . MCTS**

**5.1 Big Idea**

**6 . GTP (Go Text Protocol)**

**6.1 Big Idea**

Initialize a bot from an agent. We play until the game is stopped by one of the players. At the end we write the game to the provided file in SGF format. Our opponent will either be GNU Go or Pachi. We read and write GTP commands from the command line.

**7 . Visualization Tool**

7.1 Big Idea

**8. Web Development**

**Codes:**

**Historical Go Game Record:** <https://u-go.net/gamerecords/>

<https://u-go.net/gamerecords-4d/>

**Our Code**  <https://github.com/Go-Trojans/trojan-go>

**Go ranks and ratings**

<https://en.wikipedia.org/wiki/Go_ranks_and_ratings>

|  |  |  |
| --- | --- | --- |
| **Rank Type** | **Range** | **Stage** |
| Double-digit *kyu* (級,급) (*geup* in [Korean](https://en.wikipedia.org/wiki/Korean_language)) | 30–20k | Beginner |
| Double-digit *kyu* (abbreviated: DDK) | 19–10k | Casual player |
| Single-digit *kyu* (abbreviated: SDK) | 9–1k | Intermediate amateur |
| Amateur *dan* (段,단) | 1–7d | Advanced amateur |
| Professional *dan* (段,단) | 1–9p | Professional Player |

**Go Online Servers**

**We can submit our bot (uses GTP protocol mainly) and they can play against other online bots/human-players or can play tournaments.**

**OGS , IGS, KGS**

[**https://en.wikipedia.org/wiki/Internet\_Go\_server**](https://en.wikipedia.org/wiki/Internet_Go_server)

**Hardware Requirements**

**Refer Appendix D**

**AWS:** Deep Learning Base AMI (Ubuntu)

Deploying and Hosting : t2.small Instance

Training and Learning : p2.xlarge

## P2 Instance Details : <https://aws.amazon.com/ec2/instance-types/p2/>

1 GPU, 4 vCPUs, 61 GiB RAM, $0.9 / hour

We can explore Google Cloud Platform …

**References**

1. [**https://en.wikipedia.org/wiki/Go\_(game)**](https://en.wikipedia.org/wiki/Go_(game))
2. [**https://www.nature.com/articles/nature24270.epdf?author\_access\_token=VJXbVjaSHxFoctQQ4p2k4tRgN0jAjWel9jnR3ZoTv0PVW4gB86EEpGqTRDtpIz-2rmo8-KG06gqVobU5NSCFeHILHcVFUeMsbvwS-lxjqQGg98faovwjxeTUgZAUMnRQ**](https://www.nature.com/articles/nature24270.epdf?author_access_token=VJXbVjaSHxFoctQQ4p2k4tRgN0jAjWel9jnR3ZoTv0PVW4gB86EEpGqTRDtpIz-2rmo8-KG06gqVobU5NSCFeHILHcVFUeMsbvwS-lxjqQGg98faovwjxeTUgZAUMnRQ)
3. [**https://towardsdatascience.com/reinforcement-learning-td-%CE%BB-introduction-686a5e4f4e60**](https://towardsdatascience.com/reinforcement-learning-td-%CE%BB-introduction-686a5e4f4e60)
4. **Tromp-Taylor rules,** [**http://tromp.github.io/go.html**](http://tromp.github.io/go.html)