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DynaBot: Dynamic Dota 2 Bot

Implementation of Dynamic Scripting on AI for Three Dota 2 Characters

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***Abstract*—This research was conducted to find out whether the Dynamic Scripting method that has been used before only on zeus characters can be generalized to be used on other characters on the Dota 2 game. Dynamic scripting works by using the rulebase where the rulebase contains actions that determine the actions performed by Artificial Intelligence (AI). In addition, some adjustments have been made to existing methods. To find out whether the performance of a generalized and adjusted model is better than the previous model, a test has been conducted where AI is made with dynamic scripting against AI provided by the valve in the Dota 2 game. In addition, AI has also been tested against humans. Then the performance of AI will be analyzed by comparing the winning ratio and several other supporting variables. The results of this study are that AI got a low winning percentage against standard AI and cannot win at all and give poor performance against humans. It can be concluded that the Dynamic Scripting method cannot be generalized to other characters in the Dota 2 game.**

***Index Terms*—AI, Dota 2, Dynamic Scripting, Video Games**

I. INTRODUCTION

In 2017 64% of US households own a device that they use to play video games [1]. With these high numbers, it is not a surprise that the development of video games happened at amazing speed. Therefore, when considering how games should evolve in the future, it is wise to take into account AI that learns and directly reacts specifically to each player [2].

OpenAI, a non-profit organization has also succeeded in creating an adaptive AI for the Dota 2 game. OpenAI developed an AI consisting of 5 Neural Networks which have the name OpenAI Five that capable of defeating human amateur teams with certain Dota 2 characters [3].

To implement a Neural Network, it required hardware with high specifications because the calculation process is very complicated and constantly changes according to the action that occurs. For the game against Bot or AI, that is done offline, computation and calculation processes will be carried out on home personal computer which do not have very high specifications so that the implementation of OpenAI cannot be run by home personal computers. The alternative solution is still needed so the AI can be implemented on most computers. Other method that is simpler and has been applied for the development of AI in games is the Dynamic Scripting method.

Previous studies that have been done to create adaptive AI are "Adaptive game AI with dynamic scripting" by Pieter Spronck, Marc Ponsen, Ida Sprinkhuizen-Kuyper, and Eric Postma who applied the Dynamic Scripting method to the Neverwinter Nights game.

Dynamic Scripting is an online machine learning that uses the rulebase to produce the script. The Rulebase contains actions that can be selected, where elections will be conducted randomly with weight adjustments registered for each action [5].

Dynamic Scripting is a simpler method because with the rulebase that will regulate the actions that AI will take. The calculation process that occurs will be simpler so that computers with low specifications can still run AI without any obstacles. The Dynamic Scripting method was also applied in the Dota 2 game to create an adaptive AI in “Implementation of Dynamic Scripting on Dota 2 AI” research.

In the previous research [5], the application of Dynamic Scripting on AI Dota 2, resulted in AI for the character "Zeus" that can adapt to tactics and games from the default AI Dota 2 created by Valve. From the 50 times of learning, AI that uses the Dynamic Scripting method is able to achive a 72%-win percentage in the face of the AI Valve with unfair difficulty. Whereas to fight humans the results of previous studies have not been able to defeat humans [5].

From the research conducted by Evan Asher the problem is that in previous studies AI was made only to be used on one character and cannot be used with other characters. This research will generalize the existing models in the previous research to be used

for other characters and how the performance of other characters using the same model, whether the performance will be better or worse than the characters used in the previous research [5].

The rest of this article will be presented as follow. Next section provides a brief introduction about Dota 2 game. Section 3 and 4 describe the method and AI design proposes by this study and its evaluations. Finally, 5 and 6 explain the work of the model and conclude this study.

II. DOTA 2

Dota 2 is a multiplayer online game played by 2 teams, called Radiant and Dire, each of which consists of five players. Both teams have Ancient which must be protected from enemy attacks that came from 3 directions or called lane, namely Top, Middle and Bottom which each is protected by three towers or defenses and forces or creeps that appear on each lane. Each player chooses one from a total of 117 different heroes. Each hero has attributes that are strength, agility, and intelligence, and has 4 or more unique abilities that have many functions such as healing and strengthening friends or dealing damage, paralyzing and slowing down opponents. In addition, there are also many items that can be used to strengthen the hero [7].

Abilities and Items give each hero a role in a team, like an attacker or called a carry, which focuses on giving injuries to enemies, healers who focus on healing friends and strengthening friends, and spellcaster who focuses on deal damage to enemies with their active abilities. Carry is responsible for killing the opponent hero but requires items to reach their maximum potential. Offlaner that focuses on playing against your opponent's carry at the beginning of the game, and Supports are helping other heroes.

Each player or hero can increase the power of their hero by gaining experience points to raise his level, his unique abilities and strengthen his attributes. Experience points are obtained by killing opponent creeps or own creeps and opponent's hero. Beside experience points, players can also strengthen the power of their hero by gaining gold that can be used to buy items that help them winning the game. Gold is obtained in the same way as experience points.

There are several game modes in Dota 2, such as All Pick which is a traditional mode where playing five versus five between Radiant and Dire. There is also 1 vs 1 Solo Mid which is used in this research, which is a mode where there is only one on one battle between two heroes in the Middle lane and the winner will be determined from the first time to kill the opponent 2 times or destroy 1 opponent tower in Lane Middle.

Dota 2 also provides bots that can be played offline, which have various levels of difficulty: passive, easy, medium, and unfair.

In order to measure the level of skills of Dota 2 players, MMR system is implemented. MMR are Matchmaking Rating system where player skill defined by number. The higher MMR player has meaning they are more skillful, contrarily if the player are bad then the MMR will be low.

III. RESEARCH METHOD

In this research, the first thing to do is selecting the heroes that will be used as the object of research. The next thing that will be done is training on AI and the last one is evaluating the performance of the AI that has been tested.

A. Selected Heroes

The selected characters are the 3 most used carry heroes in the The Chongqing Major tournament, which is an official tournament organized by the Dota 2 game developer. These characters are Juggernaut used 33 times with a 45%-win ratio, Terrorblade used 31 times with a 52%-ratio, and Sven which is used 30 times with a 43%-win ratio [8].

1) Sven

Sven is a character with a melee attack and has a Strength attribute. Sven is categorized as hero category that focuses on attacking opponents with Auto Attack in combat. Juggernaut has 4 unique abilities where 3 of them are active abilities that need to be activated and consume Mana. These abilities are Storm hammer, Great Cleave, Warcry, and God's Strength [8].

2) Juggernaut

Juggernaut is a character with a melee attack and has an Agility attribute. Juggernaut is categorized as hero that focuses on attacking opponents with Auto Attack in combat. Juggernaut has 4 unique abilities where 3 of them are active abilities that need to be activated and consume Mana. These abilities are Blade Fury, Healing Ward, Blade Dance, and Omnislash [9].

3) Terrorblade

Terrorblade is a character with a melee attack and has an Agility attribute. Terrorblade is categorized as hero that focuses on attacking opponents with Auto Attack in combat. Terrorblade has 4 unique abilities where 3 of them are active abilities that need to be activated and consume Mana. These abilities are Refraction, Conjure Image, Metamorphosis, and Sunder [10].

B. Bot Structure

Based on the model from previous research, in this research AI will be divided into 7 Modes which each mode will contain actions based on the available modes. The 7 modes are Laning, Evasive, Retreat, Rune, Tower, Farming, and Attacking. Each mode will have a chance to appear based on a probability value, where the probability value is influenced by the reward and punishment received by the mode or action.

This research will be conducted on 3 heroes which each hero has a unique ability that is different from each other. AI mode will be divided into into two type, namely the general mode, which is the mode that can be used in many hero and specific modes where in that mode the action will be adjusted to the unique abilities of the hero. The actions for general mode are as follows:

1) Laning

The action in this mode are when the game starts, AI will walk towards the middle lane where the fight will take place and wait for the creep to appear and will block the creep. Blocking is an action where AI slows down the creep rate to get a more profitable battle position.

2) Evasive

The action that is in this mode is that the AI will move away from the enemy so that it is out of enemy attack range which is 500 units so AI will not receive damage or attacks from the enemy.

3) Retreat

The action in this mode are AI will return to the base to regenerate health points and mana points if AI health and mana points going down to 25%. From this mode AI will switch to laning mode when regeneration is complete

4) Rune

This mode contains an action where AI will go to the location of the appearance of the rune, which is a power up that will strengthen the AI for a certain time. After the runes are taken AI will return to the lane where the battle takes place to move to other modes.

5) Tower

Action in this mode are AI will attack the opponent's tower with a normal attack, AI will only attack the tower if there are creeps or comrades who also attack the opponent's tower, if the creep stops or no one attacks the opponent's tower AI will switch to laning mode.

For farming and attacking mode will be a specific mode. The action on each hero is as follows:

1) Sven

a. Attacking

First action is AI will use Storm Hammer's ability to finish off enemies whose health points are lower than 20%. The second action is when enemy health points are lower than 50%, AI will use Storm Hammer to immobilize the enemy, then AI will use the Gods Strength ability that will strengthen AI attack damage and strength, then AI will finish off the enemy using normal attacks.

b. Farming

First action is AI will attack creep that health points are lower than AI's attack damage and the second action is AI will use storm hammer to kill the enemy creep that health are lower than 30%.

2) Juggernaut

a. Attacking

The first action is AI will use Blade Fury's abilities and then move towards the enemy to continuously damage the opponent whose health point is lower than 25% and then continue with a normal attack. The second Action is when the opponent's health point is lower than 50%, the AI will use Blade Fury to deal damage the enemy, then the AI will use Omnislash ability to finish off opponents who still have the remaining health points.

b. Farming

First action is AI will attack creep that health points are lower than AI's attack damage and the second action is AI will use Blade Fury to kill opponent's creep by giving damage continuously to the opponent's creeps around him.

3) Terrorblade

a. Attacking

For attacking mode, there are four types of actions for Terrorblade. The first is where AI will use Reflection's ability to summon enemy shadows and attack enemies. The second AI will use the ability of Conjure Image to call its own shadow to attack the enemy. For the third, AI uses the ability of Metamorphosis to strengthen itself then AI will use Conjure Image to call its shadow and then attack the enemy along with its shadow. Last, when AI's health points become lower than 25% AI will use Sunder's ability to exchange its health

points with the opponent's health points and then attack the enemy with normal attacks.

b. Farming

First action is AI will attack creep that health points are lower than AI's attack damage and the second action is AI will use Metamorphosis to increase its attack damage and attack range which will make it easier for AI to kill the creep.

C. Bot Structure

All actions that AI has will be registered to the rulebase. Each action will have a value variable that can be reduced or increased according to the results of the action. The reward and punishment for weight will be calculated by this formula where W is Weight of each actions.

$$\Delta W = W + \text{Reward}$$
$$\Delta W = W - \text{Punishment}$$

Reward and punishment assessment will only be applied to farming, attacking, rune, and retreat modes. All action in the mode will have a variable value as well. Where the chance of the action to be selected will be higher if the value have high number. For laning, evasive, and tower modes, AI will only have one type of action because of the limited object of the research, which is 1 vs 1 mid solo which only uses the middle lane and more limited winning conditions.

Testing will be done in 2 phases. First phase AI will play against Dota 2 default bot with a difficulty level of insane in 50 matches for each character and for the second phase AI will play against humans. The subjects collected were 2 people who were Dota 2 players with an MMR of around 2500.

In the first test each AI will fight random characters controlled by the default Dota 2 AI. As for the second test each AI will fight each subject 2 times per subject using random heroes. This test is done in 1 vs 1 solo mid mode.

The action will be evaluated every 2 minutes and the weight value of the action will be adjusted based on existing parameters. The evaluation parameters for each action in each mode will be different, adjusting to the characteristics of the mode. The parameters for each mode are as follows:

1) Farming

The assessment will be considered successful if the AI manages to kill the opponent's creep in a certain amount within the time set. If AI do not succeed in reaching the specified amount, the reward obtained will not be as high as if AI succeed in reaching the set amount.

2) Attacking

When AI takes action and reduces opponent's health points, it will be compared to the number of AI own health points, if the opponents lose more health point than the AI health points then the assessment is considered successful. On the other hand, they will be considered to be failing. The number of AI health points decreases more than the opponent's health points.

3) Rune

Assessment will be conducted based on whether the runes can be taken first before the opponent is taken, if the AI succeeds in taking it first then the action is considered successful, if the opponent takes the rune first then the action is considered a failure.

4) Retreat

Assessment will be made based on whether AI managed to avoid death and return to the base to regenerate. If the AI survives, the action will be considered successful, and if the AI character dies, the action will be considered a failure.

D. Evaluation Method

Because this study uses a model from the previous study [6], then the method for evaluating results will be the same as that research. Analysis on training against default bot will be carried out based on data taken from the game, namely:

- The percentage of wins from the AI against Dota 2 default bot game.
- Gold per Minute. The amount of gold obtained in one minute.
- Experience Points per Minute. The number of Experience Points obtained in one minute.
- Total Last Hit. The number of enemy units killed in one match.

The evaluation against human will be the same as previous research. It will be done with a Likert scale with the same statement as previous research [5].

IV. EVALUATION

A. AI Test Results Analysis Against Default Bot Based on Winning Percentage

Fig. 1. AI Winning Percetage

Based on the results obtained Sven can only get 6 wins from a total of 50 matches against default bot. Juggernaut and Terrorblade can only get 3 wins from a total of 50 matches against default bot. From the test results, the value of victory is very low. And victory can only be obtained if Default Bot is a character that does not focus on fighting in the lane and leaving the lane so that AI can destroy tower or opponent's Tower easily.

B. AI Test Results Analysis Against Default Bot Based on Gold per Minute, Experience Points per Minute, and Total Last Hit

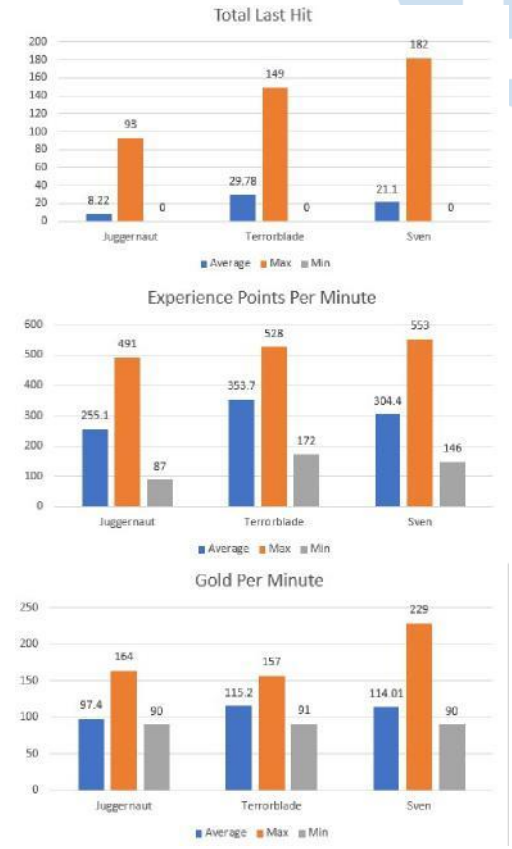


Fig. 2. AI Gold per Minute, Experience Points per Minute, and Total Last Hit

From the testing result it can be seen that Terrorblade has the highest last hit average, but Sven has the highest potential in getting last hit, it's maximum last hit is the highest among the three. AI on all characters has experienced a failure where AI cannot get any last hit at all in one game.

Whereas for Experience Points per Minute all three get maximum values that are not too much different from each other. For the average Experience Points per Minute obtained, the Terrorblade gets the highest value with a fairly significant difference with the other two characters.

For gold per minute, Sven got the highest maximum value with a significant difference with the other two characters but the average gold per minute obtained remained lower than Terrorblade. Terrorblade gets the highest average gold per minute but the maximum gold per minute obtained is the lowest, lower than Juggernaut who has the lowest average gold per minute among the three.

C. AI Test Results Analysis Against Human

In the second phase of testing, AI that has been trained against default bot will be tested against humans. The result of testing on all characters is that AI cannot defeat players at all against Dota 2 players with intermediate level player.

After testing, the players who were the subject of the test gave an evaluation of the performance of the AI in the game. The maximum points that can be earned from one subject are 25 points with the minimum number of points that can be earned is 5. The points earned by AI is 18 from the maximum points of 50.

Based on the survey conducted, it was found that the ability of AI to do last hit was so poor. Besides that, AI's ability to be aggressive and kill enemies is bad. AI isn't too bad at keeping the lane. What is good about AI performance is only in selecting items.

V. DISCUSSION

Based on the results of the testing it was found that AI was unable to obtain a high winning percentage, this is because the characters controlled by AI are characters with melee attacks. Characters with melee attacks have difficulty being able to keep a distance so that they are not attacked by enemies while having to stay within the optimal distance to provide a final attack or kill the opponent's creep.

The inability of AI to kill the opponent's creep causes AI unable to gain the experience points and gold needed to strengthen the AI character. Meanwhile, the default bot is able to get the optimal experience points and gold so that it can strengthen its character well. The character of AI cannot keep up

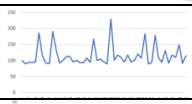
with the growth of standard AI strength, so it is difficult to achieve victory.

The parameter used by AI to maintain distance in the game is only the distance between AI and the opponent's character. To do a final attack or kill the opponent's creep, AI must enter an unsafe area. AI will back down because it feels insecure so that the AI cannot gain enough experience points and gold to strengthen itself.

A short experiment was carried out where one parameter was added, namely the number of health points from AI. If the health points of AI are still high, then the unsafe area of AI will be smaller, so that AI will get an opportunity to gain experience points and more gold that can be used to strengthen AI. The results obtained from the short experiments are not much different from using only one parameter, AI still has difficulty in carrying out the final attack or killing the opposing forces which causes the AI difficulty to strengthen itself.

Unlike the Zeus character used in the research "Implementation of Dynamic Scripting on Dota 2 AI" [5] which is a character with long range attacks so it can be easier to give a final attack or kill the opponent's creep so that it can gain experience points and optimal gold that can strengthen itself so that can get victory more easily.

The three characters used in this research also have different characteristics from the characters used in previous studies. The characters in this study are characters with power peak at the end of the game that require a lot of experience points and gold to reach the peak of their power, whereas in previous research the characters used are characters with peak strength in the beginning to mid-game. It has unique abilities that can deal big damage on opponents without lot of experience points and lots of gold.

(a)	
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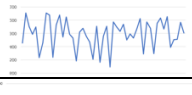
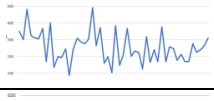
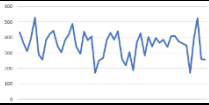
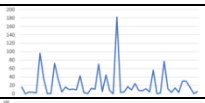
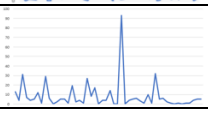
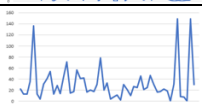
(d)	
(e)	
(f)	
(g)	
(h)	
(i)	

Fig. 3. (a) Sven gold per minute, (b) Juggernaut gold per minute, (c) Terrorblade, (d) Sven experience points per minute, (e) Juggernaut experience points per minute, (f) Terrorblade experience points per minute, (g) Sven last hit, (h) Juggernaut last hit, (i) Terrorbalde last hit. Blue lines indicate variable values for 50 games

Based on the graph shown in the picture, it can be seen that all variables have patterns that are very random. There is no trend line that can be seen. This shows that AI cannot learn from every game.

AI cannot learn because all opponents faced by AI have different characteristics. Things that learned by AI in a game cannot be used in the next game because the opponent in the next game has characteristics that are far different from the previous opponent. AI can only learn to play against one hero continuously, so AI can learn how to play against that hero. the solution to this problem is that AI must be specifically trained for facing one hero.

VI. CONCLUSION AND FUTURE WORKS

In this study AI defeated by default bot in most matches. The percentage of wins obtained by AI is 12% for Sven characters and 6% for Juggernaut and Terrorblade. In facing players with MMR 2500 or intermediate level, AI cannot win at all.

From this study it can be concluded that in generalizing the method used in the previous research [6] was unsuccessful. AI cannot learn anything from each game that AI played because opponent that AI faced have very different characteristics. For future works thing that can be tried is to give AI a different "brain" to deal with each character in the Dota 2 game.

REFERENCES

[1] "Essential Facts About Computer and Video Game Industry - Entertainment Software Association," 2018. [Online]. Available: https://www.theesa.com/esa-research/2018-essential-facts-about-the-computer-and-video-game-industry/. [Accessed 2018].

[2] David J. King, Cassie Bennett, "An Investigation of Two Real Time Machine Learnging Techinques that Could Enhance the Adaptability of Game AI," 2016.

[3] OpenAI, "OpenAI Five," 18 June 2018. [Online]. Available: https://openai.com/blog/openai-five/.

[4] Pieter Spronck, Marc Ponsen, Ida Sprinkhuizen-Kuyper, Eric Postma, "Adaptive Game AI with Dynamic Scripting," 2006.

[5] E. Asher, "Impelemntasi Dynamic Scripting pada AI Dota 2," 2018.

[6] Christoph Eggert, Marc Herrlich, Jan Smeddinck, Rainer Malaka, "Classification of Player Roles in the Team-basedMulti-player Game Dota 2," 2015.

[7] L. D. 2, "The Chongqing Major: Statistics - Liquipedia Dota 2," 2019. [Online]. Available: https://liquipedia.net/dota2/Chongqing_Major/2019/Statistics.

[8] D. 2. Gamepedia, "Sven - Dota 2 Gamepedia," 2019. [Online]. Available: https://dota2.gamepedia.com/Sven. [Accessed 2019].

[9] D. 2. Gamepedia, "Juggernaut - Dota 2 Gamepedia," 2019. [Online]. Available: https://dota2.gamepedia.com/Juggernaut. [Accessed 2019].

[10] D. 2. Gamepedia, "Terrorblade - Dota 2 Gamepedia," 2019. [Online]. Available: https://dota2.gamepedia.com/Terrorblade. [Accessed 2019].