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Bachelor Thesis

AI in Neverwinter Nights using Dynamic Scripting

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Abstract

In this paper research about dynamic scripting and the top culling difficulty scaling enhancement in the game Neverwinter Nights is investigated. A comparison between both a static and a dynamic opponent is made. The human opinion about dynamic scripting is also highlighted. To get an understanding of what the players think about and how they approach an opponent, two experiments were made. One where tests are made on a static opponent and a dynamic opponent, then a second where differences in behavior of the dynamic opponent using top culling and an ordinary dynamic opponent are analyzed. Results from the first test shows the static opponent is more preferable whereas the dynamic opponent using top culling is preferred in the second experiment. Since comparing the two experiments the results are ambiguous. The conclusion is that further investigation is needed in order to answer the question if human players prefer static or dynamic opponents when playing computer games.

Keywords: Reinforcement Learning, Dynamic Scripting, Top Culling

Guidelines to read this paper

The first section, *Introduction*, introduces the reader to the chosen subject which will be further explained in the background.

The second section, *Background*, will describe previous work and research that has been made and is relevant for this paper. The four chosen research questions will also be presented.

The third section, *Methods*, will motivate the selection of the research methods and also describe how the experiments were made.

The fourth section, *Result*, will present the results that were found from making the experiments.

The fifth section, *Discussion*, will discuss the previously presented results and add personal thoughts to them.

The sixth section, *Conclusions*, will contain a short summary of the discussion.

The seventh section, *Future Work*, will go through unanswered questions and give examples on how research can be built upon what has been done in this paper.

The eighth section, *References*, will consist of all the used reference.

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1 Introduction

Intelligence can in many ways be seen as a human resource, the ability to reason, to solve problems and learn from experience is a common denominator in terms of intelligence. “*To be intelligent means that the intellectual performance can vary on different occasions*” - Neisser et al [1]. A very important asset to games of today is the use of AI¹ (Artificial Intelligence), without this phenomenon the entertainment of the game itself would not be the same. The definition of AI itself is when a computer program creates the illusion of thinking and acting like a human and also has the ability to be rational [2].

Dynamic scripting is the main subject of this paper, it is a part of reinforcement learning². With the help of dynamic scripting the AI has the ability to perform actions and actually learn by its own mistakes. Spronck says that “*It allows the computer-controlled opponents to adapt to the way the game is being played*” [3].

Imagine a character in a game which is controlled by a script. The script is created with the help of a rule-base³, each type of character has its own rule-base. The script contains an amount of rules selected from the rule-base (see Figure 1), this will represent the character's current behavior. For example a rule can be casting a certain magical spell or attacking a specific enemy [3].

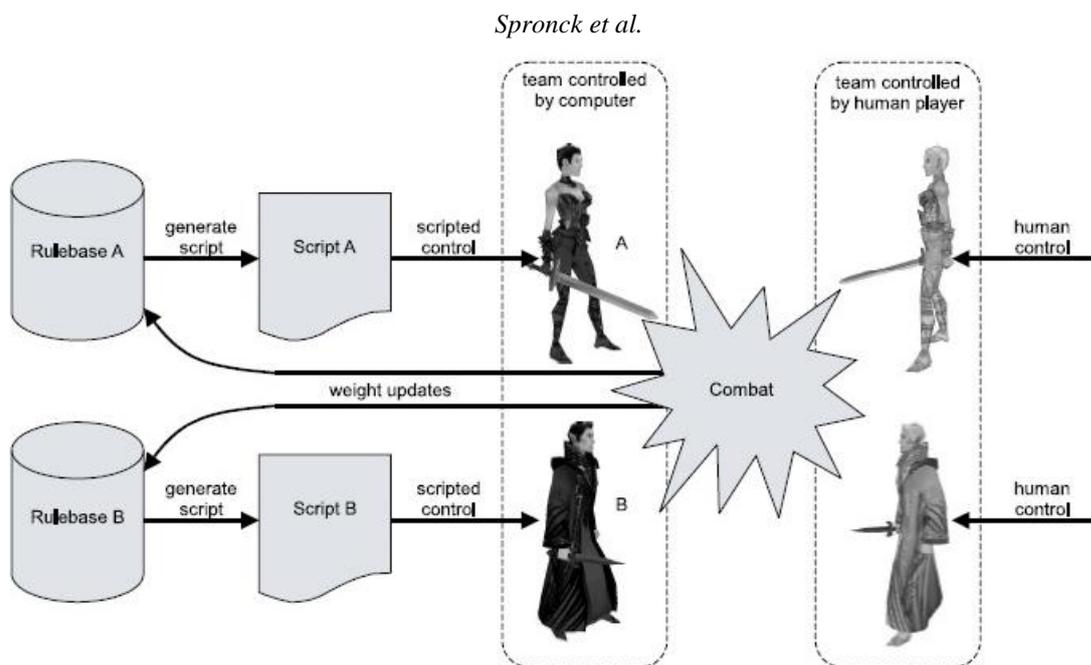


Figure 1 – Illustration of how dynamic scripting works

There are several reasons why AI is useful in games. A good AI contributes to a better gameplay and this leads to a higher replay value. In order for the game world to be more realistic, the characters in the game need to behave more intelligent. Caution must be taken when implementing the AI to prevent unexpected behaviors. Games with static AI tend to have repetitive characters. With the usage of adaptive AI the game also becomes more realistic since the characters have the ability to learn new things during gameplay.

¹ The illusion of a computer program acting intelligent

² An area of machine learning where the AI has the ability to progress

³ A set of instructions that specifies a character's behavior

2 Background

In this chapter a summary of previous research that has been found in several publications are presented. This research is relevant to this paper and gives the reader a deeper understanding of the chosen topic. A description of both purpose and objective with this work and the research questions are also presented within this chapter.

2.1 Literature Review Findings

Several papers have been written about AI and how it is used in commercial computer games. It is important that the intelligence in games is good in order for the players to be motivated to play the game. Behavior that emerges from interaction of several simpler behaviors is called emergent behavior [4]. To achieve this better behaving opponent AI the use of an online learning method is sometimes needed.

Dynamic scripting is an unsupervised online learning method used to dynamically adjust the behavior of the opponent AI [3]. It uses manually designed rules stored in an adaptive rule-base to describe the opponent behavior. These rules have a weight value associated with them and at each encounter these weights determine the rules to be picked from the rule-base and added to the opponent behavior script. There is a unique rule-base for each specific opponent type. This method meets several important requirements such as being fast, effective, robust and efficient and could thus be used in a commercial game. As a result of this, dynamic scripting has been tested for the role playing genre firstly in a battle simulation and later in the game *Neverwinter Nights* (henceforth called “NWN”).

The dynamic scripting method automatically adapts to deal with tactics that are frequently used, forcing the opposition to constantly change tactics. When choosing an autonomous behavior for the AI over a static script, several benefits are gained. Unlike a static enemy the autonomous AI can handle unexpected events and respond accordingly, which produces emergent gameplay [5].

A common factor in games is the existence of a difficulty setting. There are typically two types of difficulty settings, dynamic and static. With static difficulties there usually are a limited number of settings to choose from and it might be hard for the player to choose the appropriate setting to match his or her skills [3]. Furthermore the difficulties usually have a limited scope meaning that only opponents strength and not their tactics and behaviors are altered depending the chosen difficulty. *“Dynamic scripting changes the computer’s tactics to the way a game is played.”* - Pieter Spronck.

Since adaptive AI dynamically adjusts during battle, one possible outcome is that it will become better and more skilled than a human player and thereby beating its opposition every time. When facing a human player, adaptive AI should therefore be combined with a difficulty scaling to adjust to the human player skill to become beatable. In order to maximize the fun factor, an intentional mistake by the AI is needed [6].

Dynamic scripting with a difficulty scaling mechanism is said to have a less limited scope since it affects the tactics and therefore behavior of the opponent and it make changes automatically and not by player selection [3].

Weight clipping and top culling are two enhancements for dynamic scripting. Both these enhancements exist to achieve an even game against human opponents. With an even game it means that the strength of the computer and the human matches each other. Weight clipping uses a maximum weight value to limit the rules that are picked from the rule-base. A high value for this

weight will result in an optimal script. If the weight has a low value this will enforce in a higher diversity and most of the scripts will be mediocre. The intention of weight clipping is to enforce an even game. In order for achieving this it automatically changes the maximum weight value. The aim is to have a low value when the computer is often winning and a higher value when the computer is often losing [3]. The most complex devised AI is the one in character-based games. The goal for such games is to make the AI opponents move, react and think as human players [7].

Top culling as with weight clipping uses the same adaptive weight adjustment although the weights are allowed to exceed the maximum value. Any rules that have a greater weight value than the maximum value will not be picked from the rule-base. This means that whenever the computer-controlled opponent is often winning, the most effective rules cannot be selected, forcing the use of a weaker tactic [3]. This also means that whenever the opponent is often losing, rules that have higher weight values will be selectable leading to the use of stronger tactics.

In short this means that the weight clipping method uses variety in order to achieve and generate weak tactics in comparison to the top culling method which removes access to the most effective rules in order to gain weaker tactics. Top culling is also the best choice of the enhancements methods given this because the most reliable results are generated, it manages to force an even game against inferior tactics and it continuously learns strong behavior. *“When dynamic scripting is enhanced with the top-culling difficulty-scaling mechanism, it meets the requirement of scalability”* - Pieter Spronck.

From a player’s perspective, it is a primary concern that the game AI behaves well in order for great entertainment. This leads to enjoyment especially if the AI adapts to unforeseen tactics in real-time.

2.1.1 Dynamic Difficulty Adjustment

A technique for constantly keeping the player entertained and challenged is called dynamic difficulty adjustment. This technique adjusts the difficulty relative to player’s ability according to Scott Miller, and is used in the Max Payne game where the game is divided into levels [8]. In order to determine the difficulty, data about how the game is being played is stored after every finished level. Then before a new level the game checks the data for adjustment of the difficulty if necessary. It should not be obvious to the player when the game is adjusting its difficulty setting, this could ruin the experience and decrease the entertainment value [8].

An approach used for measuring the user experience in games is the dynamic player modeling. This method detects the player behavior and alters the game using a help or hinder mechanism. There are certain players who find a good and successful strategy and use it all the time because of the predictable win, this make the game boring and monotonous. Whenever a player is aware of that the game uses a dynamic difficulty method, there is a possibility that some new and unpredictable gameplay mechanic occur [9].

Successful captures of entertainment is important for getting an understanding on how the player actually plays the game. In order to capture this, observations on how the player acts on specific problems are made which leads to better AI methodology and reinforced entertainment in real-time. The highest entertainment is obtained when the challenge rating of the opponents is equal to the player’s skill level [10].

2.2 Purpose and Objective

The purpose is to expand our knowledge in machine learning and specifically direct our focus on dynamic scripting in the game Neverwinter Nights. The objective that we first want to achieve is to find out if a human player prefers to fight a dynamically adapting opposition. This due to that it is often static opposition that is used in computer games of today. Secondly we would like to find out whether or not the players would recommend dynamic AI and if they believe it to be the future of computer games.

2.3 Research questions

The following questions apply to the game Neverwinter nights. A quick description of the questions and how they will be answered will be reviewed.

Question 1 - Do players prefer a dynamic opponent, in that case why?

In order to prove that the dynamic scripting can be used in future games. Investigation must be made, to find out the human opinion about this adaptive technique. To investigate this, two experiments will be held. Then a comparison between the results of the experiments will be made.

Question 2 - What type of opponent behaves more like a human, the static or dynamic?

This is needed to prove if a dynamic opponent that adapts to the way the game is being played is more human like than a static opponent. In order to answer this question an analysis of the statistics from the first experiment will be made.

Question 3 - According to the players what type of opponent has the highest entertainment value and why?

The AI in games must not only be intelligent but also entertaining. Both analysis of the statistics from the first experiment and the results from comparing the two experiments will be taken in consideration.

Question 4 - What do the players think about top culling?

Top culling is a difficulty scaling that applies to dynamic scripting. It takes the players skill into consideration and scale its own skill level either up or down depending on how the player plays the game. It is important to find out whether the players prefer a match against an opponent with equal skill level. The results from the second experiment will be reviewed when answering this question.

3 Methods

The purpose of this paper is to investigate people's thoughts and opinions about the dynamic scripting. In this chapter a further explanation of the used methods to preserve this purpose will be made.

3.1 Approach and methodology

This paper uses both deductive and inductive ways of reasoning. It is deductive since the research is based on earlier studies about dynamic scripting made by Pieter Spronck. This way of reasoning is often called the top-down approach. It is also inductive since the goal is to find out what makes Game AI interesting and entertaining for the users of the game. This often goes under the name bottom up approach.

In order to answer our research questions, two experiments has been made using a custom Neverwinter Nights module based upon the existing module "Online Adaptation Neverwinter Nights module, version 3" made by Pieter Spronck. The module is representing an arena where creatures of opposing faction can fight each other. You can fight against both a "static opponent"⁴ (henceforth called 'SO') and a "dynamic opponent"⁵ (henceforth called 'DO').

The purpose of the first experiment was to test and determine the differences of intelligence and predictability of both the static and the dynamic opponent. The second experiment was aimed to test the top culling method described in subsection 2.1 and compare it with the DO not using the method. In the end a comparative analysis is made on both of the experiments.

The paper uses a quantitative approach, this because statistics were gathered from the first of the two experiments. The statistics were used in order to measure the entertainment value of the dynamic scripting. This paper also uses a qualitative approach, this due to that we try to discover patterns in people's thoughts about playing against the different opponents.

3.2 Literature Search

In the beginning of the research a search for literature regarding reinforcement learning and dynamic scripting was made in Google Scholar using keywords as "dynamic scripting", "adaptive game AI" and "reinforcement learning". Scientific articles were also found on Pieter Spronck's webpage: <http://www.spronck.net/>.

3.3 First Experiment

A group of 21 people were invited to participate in the experiment, among them there was 18 men (most of them in their twenties) and three women (24, 26 and 35 years old). The majority of the participants regularly play a computer game, this is the main reason for why they were chosen for the experiment.

A survey was used to collect data for this experiment. According to Peter Giger a quantitative method gives the researcher more control over the test situation [11]. This since a survey uses predefined answers.

⁴ An opponent that has a common behavior

⁵ An opponent that is adaptive and changes tactics

3.3.1 Preparation

The modules in Neverwinter Nights are built and edited using Aurora toolset and the earlier mentioned module used for this experiment has been altered. For example items to enhance the PC (player controlled character) were added to the module in order to decrease the level of difficulty and make the environment more enjoyable for the players. The additional items that were added include an amount of “health potions”⁶, a modified “wizards robe”⁷ to make the PC stronger and finally a modified long sword used to decrease the health of the enemy.

3.3.2 Execution

At first when the participant arrived for the experiment, he or she was informed about the game and shortly how to play it. If the participant never had played the game before a longer explanation were required. After this two matches consisting of ten rounds should be played, each of which the player should fight against both the DO and the SO. The choice of opponent was a wizard that could use numerous magical spells as its main attack. This opponent was chosen because of its diversity in attacks, which we believe leads to a more interesting battle.

In the first match the player fought against the DO and in the second match the SO, although nothing about this were told to the player. The basic idea with the experiment was that attention should be turned to the opponent’s behavior, and then a survey about the match should be answered after each set of rounds. In the end there was a summary where the participant was told to compare the two opponents. In the survey the testers answered the following questions (see figure 2 and 3).

The image shows a survey form with five questions and their corresponding answers. Each question is followed by a horizontal line. The questions and answers are as follows:

- Question: **Do you play computer games? ***
Answer: Yes
- Question: **What is your previous experience with Neverwinter Nights? ***
Answer: 1 2 3 4 5
None ○ ○ ○ ○ Great
- Question: **Was there any opponent that behaved better than another? ***
Answer: No, both opponents behaved likewise.
- Question: **Did any opponent behave more like a human player? ***
Answer: Yes, the opponent from the first match.
- Question: **Which opponent would you rather meet again? ***
Answer: The opponent from the second match.

Figure 2 – *These questions were answered at the end of the test*

⁶ A magic potion that gives the PC health when it is damaged

⁷ Magical clothing that the PC can wear

How entertaining was the first match? *

1 2 3 4 5

Very Boring Very Fun

Was there anything in particular that made the first match boring / funny?

How difficult was the first match? *

1 2 3 4 5

Too Easy Too Hard

Was there anything in particular that made the first match easy / difficult?

Was the opponent in the first match predictable? *

Yes

Was the opponent in the first match intelligent? *

Yes

Use this field to write your own thoughts about the match

Figure 3 – *These questions apply to both of the matches and were answered after every match*

3.4 Second Experiment

For this test five people were invited to participate, two women and three men, they were invited because of their great dedication to games. Based on own experience, the dedication often leads to greater understanding to games in general.

The method that was used for this experiment was an interview described in section 3.3.2.2. A qualitative method describes the characteristics of a phenomenon [12].

3.4.1 Preparation

As in the first experiment the same module and opponent for testing was used. After the first experiment the discovery of just having melee and ranged weapons were found. Therefore a decision to remove all the enhancing items except the health potions was made. Instead the PC now was equally strong as the wizard opponent and also could cast the same spells (see figure 4). The expectation was that a more even game would be played this way.



Figure 4 – *A collection of different spells that could be cast in the second experiment*

3.4.2 Execution

At arrival the test person was given a brief explanation about how to cast spells and play the game in general was given. This time the participant were informed about its opponent before each battle, and also prompted to analyze the behavior of the opponent. The player was encouraged to only fight with spells. This due to that in the first experiment the attacks from the test person became rather monotonous. The experiment differs from the previous one, since this test only take the dynamic opponent in consideration.

At first the player should play a battle of 15 minutes against the DO using top culling, during this they were observed and their tactics during the battle were noted. When 15 minutes had passed the test persons were told to take in consideration that the top culling was deactivated. Now the player should play 15 minutes against the DO with no top culling.

In the end of the experiment a structured interview was made. In the interview the following questions were asked:

- Is it true that your first opponent was the most entertaining one (this opponent used top culling)?
 - If no what made the second opponent more entertaining?
- Did it feel like the first opponent was too easy?
- Would you prefer to meet the first opponent once more?
- Do you think the kind of opponent as the first one is applicable in games of today?
- Do you agree that an opponent that learns while the game is being played is better than an opponent that do not?

The test persons were interviewed one at a time. This due to that deeper analysis of the unique test cases was needed. It also prevented the test persons to influence each other. The choice of these questions was to lead the answers to a more limited way, meaning that the results would be easier to compile than with the results in the first experiment where the answers were wider to the character.

4 Result

This chapter will go through the results from both of the experiments. First the results from the quantitative experiment will be shown. In section (4.1.1) a review of the results from testing the DO will be made and in section (4.1.2) the results from testing the SO is presented. As two opponents were tested in this experiment a comparison between them will be made in section (4.1.3). The statistics gathered from this test can be seen in section (4.1.4). In the end of the chapter the results from the second experiment will be reviewed (4.2).

4.1 The first experiment

In this section the results from the two matches are presented and compared. As mentioned before both the static and the dynamic opponent were tested in this experiment.

4.1.1 Results of testing the dynamic opponent

From the test results it is shown that the users rated the matches against the DO to be predictable (see Figure 5) and some even said it not to be at all very challenging. An equal amount of testers had different thoughts about the match, the first half showed a clear sign of disapproval and the second one said it was of great entertainment (see Table 1 - Question 1a) in (4.1.4). The same appeals to the difficulty where the first half thought it was too easy while the second claimed it to be too hard (see Table 1 – Question 2a). Testers reported that sometimes the DO would use a really powerful spell, knocking them to the ground. A common factor that was considered when answering the form was the randomness of the matches. This caused frustration among some players and they considered the match to be less entertaining. Also 12 out of the 21 testers do not believe the DO to be intelligent. This can be seen in Table 1 – Question 4a.

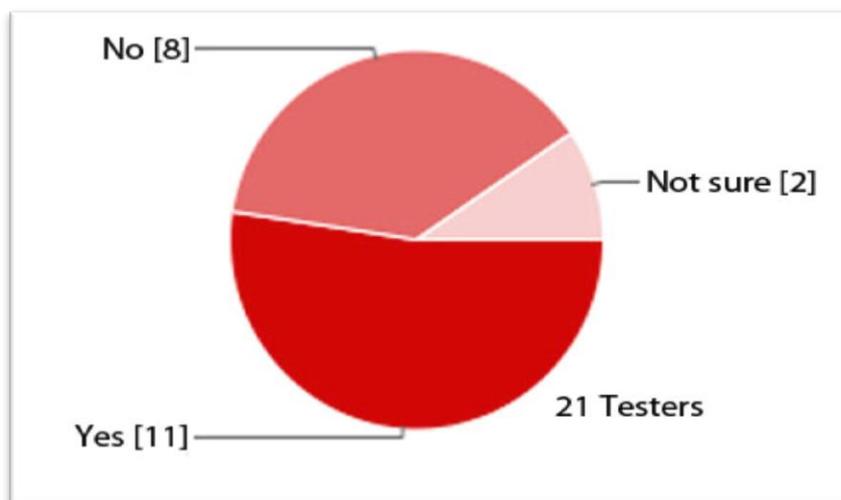


Figure 5 - 11 out of 21 observed that the opponent was predictable.

4.1.2 Results of testing the static opponent

According to the results of the experiment, the SO was both entertaining and difficult to fight against. Common elements during the fights were that the computer controlled opponent used a variety of spells and took advantage of health potions when low on health. The testers noticed a stronger resistance from the SO compared to the DO. During one fight the SO stood mostly still and

rarely moved, even if hit by the player who were close. This made some testers express boredom and made them feel that the opponent was less intelligent. More than half of the participants said that the opponent from the second match was predictable.

There was a particular spell “*Evard's black tentacles*”⁸ that has a high risk of causing paralysis to the player. Once a player gets paralyzed, all actions are disabled during a set amount of time which makes the player very vulnerable and exposed to damage. The experiment showed that the SO frequently used this spell and that the testers noticed a larger resistance.

In certain rounds it was clearly stated that a longer survival was possible. Nearly half of the test group found that the second match was very fun, also the same amount found that the level of difficulty was very good.

4.1.3 Comparison between the two opponent types

The majority of the test group had never before played NWN and only a few had good knowledge and experience from the game. Evidence shows that the SO behaved in a way which made it better than the DO in practice. Half of the test group felt that the SO had a more human way of playing, whereas the others could not see any difference between them. As much as 33% of the participants favored the SO in all the questions. They thought that it had the best behavior, that it was more human-like than the DO and surely that this was the opponent of their choice (see Figure 6).

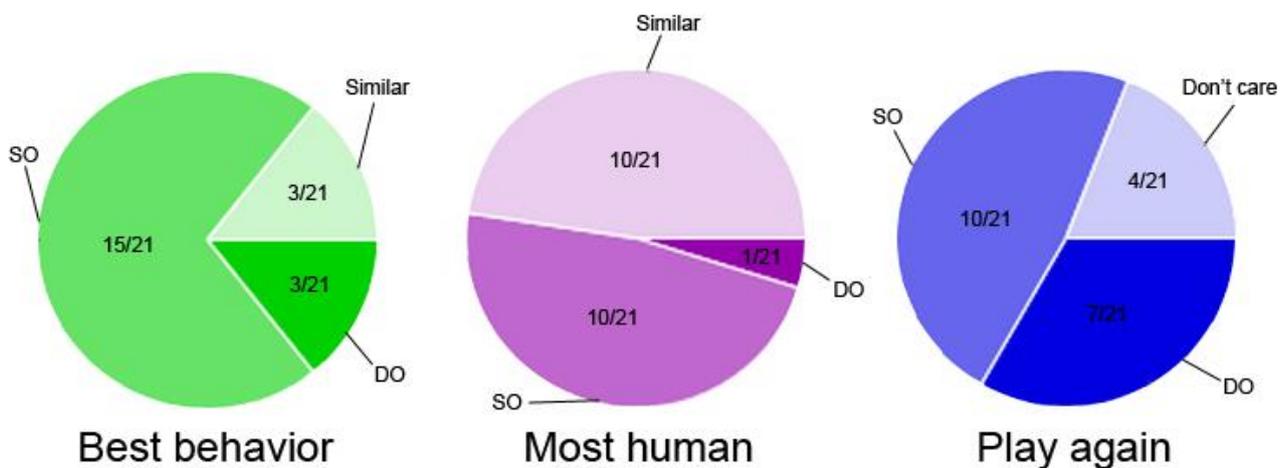


Figure 6 - Differences between the opponents

According to the survey the SO had the highest entertainment value. The level of difficulty in the first match was too easy. This was based on the data regarding the first test, which showed that 10 out of 21 people thought the difficulty was below their skill level. The first opponent was clearly stated as not intelligent, 12 out of 21 thought this. In the second match the majority of the testers thought that the opposition was even, this can be seen in table 1 in question 2b.

⁸ Magical tentacles rises from the ground and is capable of grappling a target

4.1.4 Answers to the statistical questions

In this section a review of the answers to the questions that gave statistical data is given. As can be seen to the right in the table, a T-test was performed giving a P-value on the questions. The test is a statistical test that shows the probability of the data.

1.	Very Boring	1	2	3	4	5	Very Fun	P-Value
a) How entertaining was the first match?		2 of 21	6 of 21	5 of 21	6 of 21	2 of 21		0,86
b) How entertaining was the second match?		0 of 21	4 of 21	7 of 21	6 of 21	4 of 21		0,83
2.	Too Easy	1	2	3	4	5	Too Hard	
a) How difficult was the first game?		4 of 21	6 of 21	4 of 21	6 of 21	1 of 21		0,86
b) How difficult was the second game?		1 of 21	4 of 21	11 of 21	5 of 21	0 of 21		0,18
3.		Yes	No	Not sure				
a) Was the opponent in the first match predictable?		11 of 21	8 of 21	2 of 21				0,51
b) Was the opponent in the second match predictable?		12 of 21	5 of 21	4 of 21				0,51
4		Yes	No	Not sure				
a) Was the opponent in the first match intelligent?		3 of 21	12 of 21	6 of 21				0,48
b) Was the opponent in the second match intelligent?		7 of 21	7 of 21	7 of 21				0,3
5		Yes	No					
Do you play computer games?		20 of 21	1 of 21					0,34
6	Beginner	1	2	3	4	5	Expert	
What is your previous experience with Neverwinter Nights?		12 of 21	3 of 21	2 of 21	2 of 21	2 of 21		0,55
7		DO	SO	Same behaviour				
Was there any opponent that behaved better than another?		3 of 21	15 of 21	3 of 21				1
8		DO	SO	Same behaviour				
Did any opponent behave more like a human player?		1 of 21	10 of 21	10 of 21				0,61
9		DO	SO	Doesn't matter				
Which opponent would you rather meet again?		7 of 21	10 of 21	4 of 21				0,35

Table I - This table shows statistics on what the testers thought about the matches, there were 21 testers. For example 15 of 21 refer to 15 testers.

4.2 The second experiment

There were some unique spontaneous reactions about how entertaining the opponent using top culling was. As translated from the interviews “Yes, it felt like it adapted better than the other.” and “Yes, it varied both in behavior and the level of difficulty.” Regarding the first quote it is obvious that an adaptation in the opponent using top culling was more visible to the human eye. The second quote shows that with variation of both behavior and difficulty the entertainment value is higher.

Whether or not the opponent using top culling was too easy there were different responses. One interesting quote was “No, the level of difficulty was enough”. By analyzing this quote it shows that the top culling work as intended, if the difficulty for this specific test case always was enough. Another quote regarding this topic was “No, it felt harder” this does not match the previous analysis at all, but should also be taken into consideration.

On the question whether or not the opponent with top culling was applicable on games every test person had similar quotes. One of them was “Yes I believe so, it will always be just enough resistance since it adapts”. According to the similarity of the different answers on this question the results clearly shows upon an advantage for the dynamic scripting using the top culling.

Regarding the last interview question, where a dynamic opponent is said to be more preferable than a static one. It is confirmed that this is true by one of the testers who says “Not as monotonous, I think it fits much better in that it gets much better resistance.”

5 Discussion

The reason for our choice of topic “AI in Neverwinter Nights using Dynamic Scripting” is that previous research points that dynamic scripting is possible to be used in games. The question was asked whether or not the users can notice the difference between the ordinary AI of the game and the dynamic scripting. This relates to our first research question, whether or not the users care for an AI that is able to learn during gameplay. What type of game genre that this is most suitable for is also an interesting question.

What came to our interests was the research of Pieter Spronck. The results of his research is that dynamic scripting is indeed usable for a CRPG (Computer Role Playing Game), what he did was testing the technical aspects of the scripting. He focused on the algorithms and how to scale the difficulty according to the opponent. This he did AI against AI, not with actual human players. Our focus lies on the human opinion about the dynamic scripting, and also the entertainment value.

According to the first experiment, it was said that the DO is predictable. By analyzing this the following questions came to mind, (i) could the experiment be formed in another way? (ii) was the difficulty too easy for the DO so that it used the same spell over and over?. The answer to question (i) in this case would be that if we would redo the experiment, a similar test case as in the second experiment would be used. This came to our knowledge because many testers in the first experiment complained that the opponent used more powerful spells than the player itself could cast. Speaking of the second question the lack of knowledge of the opponent's experience level lead to that the opponent was more powerful this lead to an uneven match. The DO maybe found that using the same spells over and over was the most effective tactic since it felt too easy for it to win the battle. Without top culling it has no inhibitions.

Regarding that the testers noticed a stronger resistance from the SO compared to the DO. The answer to this could simply be that the SO since it is static could be programmed to withhold a certain level of difficulty. Since the skill of the player is varied, the question which level of skill the player should have when facing such a static opposition arise. For example would the seemingly expert player feel that the SO had a stronger resistance or would he or she just feel too bored?

What this test showed was that the SO behaved more like a human and were much better than the dynamic. This was in favor of the static opponent, our expectations about the results were that it would show that the DO was better. If the test was made as the second experiment would it show different results? What results would be given if also the DO using top culling would be added to this experiment? Maybe the testers would then be able to fully compare the different opponents.

One important thing regarding the first experiment is the order in which the testers fought the opponents. In the first match all of the testers fought against the DO and in the second match against the SO. This might have an impact on the result of the DO since a majority of the testers were new to the game and therefore maybe did not pay as much attention to the opponents behavior as an experienced player. Due to this the experiment might have given us misleading data. One solution would be to allow 50% of the testers to play the first match against the SO and another 50% against the DO. This might give more variation to the experiment and the testers might notice different things in the opposition.

It is interesting that in the second experiment all of the testers enjoyed the DO with top culling, which uses the difficulty scaling method. From the analysis of the results difficulty scaling was said to be approved for commercial games. Their opinion about the DO without top culling was not taken into consideration for this test since it was only used as a comparison.

After finishing the experiments two more questions came to mind. (i) What would happen if the player fought in a team? (ii) If the team used dynamic scripting how well would they cooperate with the player? Maybe dynamic scripting could be the future of companions in games. But since no tests on these matters were made in this paper, it is hard to answer these two questions without further investigation.

When comparing the results of both experiments, it is shown that both the SO and the DO using top culling were most preferred. Questions arise whether or not the dynamic is better than the static. This is important to find out since it can facilitate for future developers of game AI if they know what the players want. We make an assumption that the DO using top culling is better than the SO and also that the players think this opponent has the highest entertainment value. This due to that based on the analysis of the second experiment there were strong signs of liking and enjoyment of this opponent.

6 Conclusions

Two questions that were raised during the research, (i) Do the users care for an AI that is able to learn during gameplay? (ii) What type of genre would this be most suitable for? The research is based on the work of Pieter Spronck about dynamic scripting. We take the human opinion about this kind of technique in the first place. This is important since the wish is to convince future developers of game AI that an adaptive way of doing it is working well.

According to our first experiment it is shown that the most preferable opponent used static behavior. The experiment also shows upon that the SO behaved more like a human. Is this a reliable result to trust on? Is it that the SO was more entertaining since it offered larger resistance?

We expected that the results of the first experiment would be in favor of dynamic scripting. Whether or not the preparation and execution of the experiment was right or wrong could be questioned.

From the second experiment that was qualitative, where a deeper analysis of the dynamic scripting was made, the results show upon a great liking of the DO using the top culling. We also think that this experiment's preparation and execution was better than the first.

7 Future Work

When doing this research and the experiments, the test groups were composited of both men and women. It would be interesting to compare the differences in opinions what men and women separately have to say about dynamic scripting. These opinions could then be compared and conclusions could be made. For instance one thought would be that the dynamic scripting is better suited for games where the majority of the players are men.

Since there are not satisfying answers to all of the research questions, further testing needs to be done to determine what the best suited opposition would be. For instance what needs to be tested is the SO that was preferred in the first experiment versus the DO using top culling from the second experiment.

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