Implementation and Analysis of a Non-Deterministic Drama Manager

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***Abstract*—Adaptive interactive storytelling is a resource used to guide the player through the game narrative in a way he/she can understand, in his/her own unique way, the multifaceted nature of the story being told. In interactive storytelling, the player is presented with a set of options to help direct the narrative, and the Drama Manager (DM) is responsible for controlling the narrative trajectories the user will experience. This work proposes a DM based on a genetic algorithm, which will be able to present non-deterministic plot lines to the player, increasing replayability. The proposed DM will follow the Anthropological Structures of the Imaginary proposed by Durand to guide the narrative, which will be the basis for a player model. Experiments were performed both with synthetic datasets as well as eleven players. The results show the GA finds subsets of plot lines that are not far from the optimum while increasing replayability. Qualitative analyses of the players preference considering the three regiments that defined Durand's theory show it is appropriate to model the players preferences in interactive storytelling.**

***Keywords*-Adaptive interactive storytelling; genetic algorithms; replayability.**

I. Introduction

In recent years we have seen a boom in game production. When we look at computer games, we observe that 38% of the games available on the online gaming platform Steam were released in 2017, with an average of 21 games been released per day [1]. Big game studios have the resources to work and make their games in the speed and quality demanded to stay relevant in such a crowded market. However, independent game studios often need to seek other ways to stand out.

One of the ways that have been successful in bringing attention to smaller game studios, or even individual game developers, is through focusing on different approaches to narrative [2]. Interactive storytelling systems envelop the simulation of emotional response in agents, game environment changes, character features, the incorporation of newer Artificial Intelligence (AI) developments on game development and drama management [3]. Taking advantage of these features, independent game developers started to explore video games as a cultural artifact to share their life experiences. We can see this in games like the commercially and critically acclaimed Gone Home [4], which was created by a team of 9 people and focused mainly in narrative.

At the same time, with several games competing for attention, many game developers turned to procedurally generated content to speed up and dynamize the development process. This is no exception for narrative-driven games, which opened up the space for researchers to explore adaptive interactive storytelling. The idea of these systems is to guide the player through the narrative in a way they can understand, in their own unique way, the multifaceted nature of the story being told.

When working with interactive storytelling, we can represent the narrative as a graph, where the nodes are important plot points and the edges are the conditions to move from one plot point to another. In an adaptive narrative, the nodes available to the player at any given moment are a way to direct the narrative, and the structure that controls and handles this process is called Drama Manager (DM). In other words, the DM implements the method that will decide which nodes in the narrative graph will be exposed to the player, guiding the narrative trajectories the player will experience.

The main objective of this work is to create a Drama Manager to handle interactive narratives by focusing on the aesthetic experience of the player, adapting the story to the themes the player favors, and wrapping the game story to create a unique and coherent narrative experience for each player. In order to account for the creation of unique stories, we will model a genetic algorithm to build the drama manager. The genetic algorithm is chosen because it is able to generate non-deterministic plot lines for the players, increasing replayability, as well as dealing with large plot lines.

In general, DMs guide the narrative of the game by relying on some form of narrative theory. The most common used theories are Freytag's Pyramid [5], which can offer support when modeling story tension, and the monomyth or Hero's Journey [6]. Both of these theories are limited when dealing with game narratives, as they predict only stories within a very narrow aesthetic experience. To counter this limitation, our DM is based on the Anthropological Structures of the Imaginary proposed by Durand [7] (see Section 2 for more details). To the best of our knowledge, this theory has not been explored in interactive storytelling before.

To choose which and how the overarching stories will be presented to the player, we need to understand who the

Figure 1. The Hero's Journey Story Pattern.

character is becoming in the hands of the player as the game progresses. This will be done using a simple player model that will be updated in game runtime to keep its understanding of who the player currently is.

With that in mind, we want the DM method to be capable of creating unique and coherent narratives that fit the player profile, increasing player autonomy and replayability. We also want the method not to hinder the author capacity to control the story. We will evaluate whether the method meets our requirements by focusing on authorial control, player autonomy and adaptability and replayability, four of the ten features described on Section II.C.

II. Approaching Adaptive Narratives

In this work, Interactive Storytelling is defined as an adaptive story which represents multiple facets of the same story world depending on how the player is interacting with the plot. Attempts to use AI to manage Interactive Storytelling through the use of a DM often use strict linear concepts, such as the Hero's Journey or monomyth [6] or Freytag's Pyramid [5] to organize how the narrative will change as it adapts to the player. These approaches often limit the narrative to a story where the player will often experience a conflict based storyline, independent of the content in the story. While conflict-based stories are more common, it is possible to expand the set of possible stories that the player can experience if we try to understand not only what type of the content the player wants to see, but how they want to experience it and use this knowledge to guide how the content will be generated.

A. The Hero's Journey and Freytag's Pyramid

The monomyth is a pattern commonly found in stories, and was first described by Joseph Campbell's in his book "The Hero of a Thousand Faces" [6]. It can be found in several works of fiction and myths, such as the myth of Prometheus, The Star Wars Movies and most of Disney's works [8]. According to this concept, the protagonist goes through the motions of twelve main plot points during the course of a story, as illustrated in Figure 1.

The core theme of the Hero's Journey is rising above, overcoming problems. The clear-cut structure of this concept is attractive when dealing with drama management, as there is a pattern the method can follow in order to guarantee a cohesive story. However, it is also quite limited in the sense that the story it creates is fueled by conflict and thus will yield similar narratives. When every story created must be based on a conflict that has to be overcome, many narratives are left out. While the Hero's Journey has been widely used to construct narratives, in order to create a drama manager that can fulfill a wider range of stories, it can be beneficial to look into more diverse narrative structures.

Freytag's Pyramid follows a similar structure than the hero's journey, but in less detail. Freytag models the classic narrative as a tension line that describes five moments: (i) exposition, in which the fictional world and the initial situation of the protagonist is presented; (ii) rising Action, the moment to build up tension as preparation for the climax of the story; (iii) climax, the point that changes the protagonist's destiny, and when things will start to go in their favor or unravel depending on the tone of the story; (iv) falling action: this is when the final course of the story is set, with all the actions leading to the end being set up and the build up of a final suspense moment; (v) denouement: on the moment all the loose plot points are tied, the conflict is resolved and there is a return to normality.

Because of the lack of detail in Freytag's concept, many variations of stories can emerge, as long as the stories created follow the tension flow delimited by the Pyramid. While this theory can be tempting to use due to its descriptive rules in narrative format, it is also constricted to a small set of possible story structures. The choice of any of the two concepts aforementioned to adapt a narrative implies in the exclusion of stories with different rhythms and flows.

B. The Anthropological Structures of the Imaginary

A different approach to narrative structure is Durand's Imaginary [7]. The author proposes that the imaginary is a collective of images, symbols and their relationship to culture and the stories that can be told with them. The imaginary is divided in three main regiments: diurnal, nocturnal and synthetic. The diurnal regiment is composed of only one dominant scheme, called postural or diurnal, and it is characterized by images, patterns and stories that have a clear division between good and evil. Here the hero needs to overcome hardships and remain pure and uncorrupted. Both the Hero's Journey and Freytag's Pyramid can be understood as examples of a diurnal pattern in narrative.

The nocturnal regiment has an inversion of meaning of the images of the diurnal regiment. In this regiment the protagonist accepts the passage of time instead of facing it

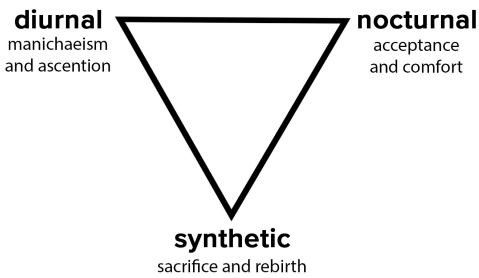

Figure 2. The three schemes of the imaginary

as a conflict to be solved. In this set of images the narrative patterns are not based on conflict, but in acceptance and exploration. The synthetic regiment, in turn, comprises the patterns of cycles. It harmonizes the images of the nocturnal and diurnal regiments so they can exist in the same narrative. For instance, this can be observed in stories about sacrifice, where the death is accepted, but with a goal in it [9]. These two regiments do not necessarily need conflict to create a story, and the drama manager can greatly benefit from them.

The concept of the imaginary understands narratives as complex structures and proposes a way to organize its parts and symbols. By using Durand's narrative theory to understand players models, we can guide the narrative to stories that are more well-linked to their interests and present the plot points to the player in a way that will be coherent with their style of play. The player model will explain how interested the player is in each of the regiments, and this will help the drama manager to guide which images and types of stories the player will encounter in the game. This differentiates this method from the monomyth approach to narrative management, where there is a clear and single structure of what the final narrative will look like. With narrative regiments that value other forms of engagement, the stories generated can be based on a more diverse set of rules and thus create a larger set of experiences.

The nocturnal and synthetic regiments introduce the possibility of non-combative game play and narratives for players who are not interested in conflict-based stories and that would have no other option if the game could only generate stories based on the Hero's Journey or on Freytag's Pyramid. So by using the three regiments of the imaginary we believe that the drama manager will be able to provide a more nuanced guidance for the narrative generation.

C. Drama Manager

Many different approaches to drama management have been proposed in the literature, as reviewed by Roberts and Isabell [10]. They listed a set of 10 features for analysing DMs, taking into consideration how these features impact game developers using the DM and the players interacting with the final product. These features are:

- Speed: the DM decision making should not cause perceptible delays for the player.
- Coordination: Non-Playable-Characters (NPCs) should act to improve the experience of the player.
- Replayability: the game experience should continue to be engaging even with multiple replays.
- Authorial Control: The intent of the game author for the story remains even with the actions decided by the DM, and should influence the experience of the player.
- Player Autonomy: The actions of the DM should not stop the players from pursuing their goals and impacting in the game world with their actions.
- Ease of Authoring: the burden of authoring an interactive narrative should not be increased because of the use of the DM.
- Adaptability: the player's individual characteristics should be taken into consideration in order to change the game experience.
- Soundness: One should be able to verify claims made about the system used as a whole, not just the solution it proposes.
- Invisibility: the DM's interference in the game should not be overtly manipulative to the player.
- Measurability: Both players and authors should be able to provide a measurable feedback of their set of experiences and the use of the system, respectively.

From those 10 features, this paper will focus on four: (i) replayability, (ii) authorial control, (iii) player autonomy and (iv) adaptability. These features were selected to help to conceive a method that will focus on the tension between authorial intent and player experience. As discussed in Section 3, most of the methods previously proposed in the literature address replayability but do not address adaptability and vice versa. Something similar happens to authorial control and player autonomy, with only one work capable of handling both features at the same time.

III. Related Work

When we look at procedural content generation for video games several efforts have been made to push the boundaries of this discipline. Researchers have explored this subject from terrain generation to game rule sets [11]. Togelius at al., for example, in their explorations of possible goals for procedurally generated content for video games, identified the use of player directed generation of content coupled with player model selection as an interesting point of research [12]. When we talk about drama management guided by player models, the methods tend to fall into this category of procedural generated content directed by player model selection. In this section we will discuss previous work using the four desirable features of a DM previously defined.

In the search for replayability and player agency, we can find efforts in the field of emergent narratives, such as Bevensee's work on the use of one player's experience as a

Table I. How the features of interest appear in related works.

Works	Features			
	Replayability	Adaptability	Player Autonomy	Authorial Control
Min et al. [16]				X
Harrison et al. [17]		X	X	
Bevensee et al. [13]	X		X	
Roberts et al. [14]	X			X
Thue et al. [15]		X	X	X
Sharma et al. [18]		X	X	
Hodhod et al. [19]	X			
Yu et al. [20]		X		X
Barber et al. [21]	X	X	X	X
Justo et al. [22]	X			X
Our Method	X	X	X	X

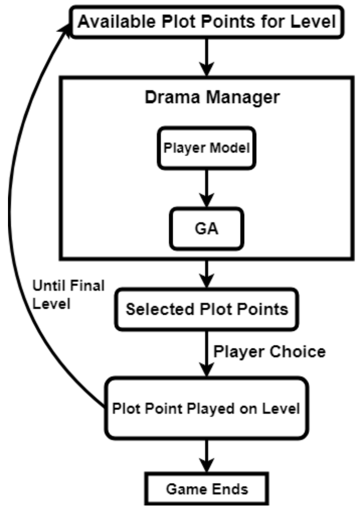

Figure 3. Drama Manager Flow

source of variation in the game world for the next player's run of the game [13]. This approach addresses the replayability problem and creates possibilities for the player to directly influence the game world, which guarantees Player Autonomy. However, it does little for Authorial Control or Adaptability as the changes in the game are completely outside of the author's control and can not be changed to better fit a player's profile.

Another interesting approach is the Targeted Trajectory Distribution Markov Decision Processes (TTD-MDPs) [14], which presents a less deterministic possibility for interactive drama and addresses the replayability problem directly. This system controls the narrative flow using a set of states, actions, state transitions trajectories and a distribution of probabilities attached to each trajectory. This method also guarantees replayability while sacrificing adaptability. However, the use of TTD-MDPs takes a step towards Authorial Control even if it limits the large Player Autonomy proposed by Bevensee's method. Here we also have an attempt to use algorithms as a way to actively manage the game story, while on the last approach the changes were not curated by an AI.

The PaSSAGE [15] system changes the focus of the solution and sacrifices replayability in order to grant adaptability, authorial control and player autonomy. Their player model is based on five possible pre-defined player styles, and updated based on the player actions and the annotations of game events provided by the author. Actions types on the game are annotated with weights, and when the player executes these actions his style vector is updated accordingly. The system then chooses from the set of possible events the most attractive for the player given its style vector.

PaSSAGE does not account for replayability, and a set of player choices will lead to the same player style being chosen. Since the traversing of the narrative graph is only controlled by the player style and the weights on the narrative vertices, this will lead to a deterministic path in the story. PaSSAGE's player styles are also limited in the Hero's Journey approach to storytelling, which can lead to repetitive and generate simple story structures.

The system proposed by Sharma et al. [18] learns the player's preferences for certain plot points in order to guide the narrative flow to the next best option. This approach favours adaptability and partially player autonomy while sacrificing authorial control and replayability. Hodhod and Magerko [19], in contrast, propose a system for narrative management focused on human-computer collaboration for narrative creation. This system prioritizes the creation of a shared narrative between player and AI, without much interest in the author's intent for the story.

A system based on Freytag's Pyramid is presented by Justo and Bittencourt [22] and uses fuzzy-logic to generate narrative beats, select characters and guide the personal narratives of the players. During the tests they conducted an issue seems to arise as players that have no interest in conflict based stories place the algorithm in a dilemma. The paper describes that the system would try to create the classical tension arc for the Pyramid and the players that had no interest in conflict do not interact with the narrative in the expected way, causing the system to become stagnant and the players to become dissatisfied with the experience. This is a good example of too much Authorial Control in detriment of Player Autonomy and Adaptability.

There is also the method of sequential recommendation of plot points for interactive narratives [20], which handles the narrative sequence as a recommendation problem, where the DM will recommend the next plot points taking into consideration which plot points will yield a story that the player is most likely to enjoy. While it creates adaptability and allows for great authorial control, this approach completely ignores player autonomy and does not add much replayability to the stories.

In the survey presented in [10], a pattern that can be observed is that most analyzed systems makes a compromise between replayability and adaptability, with the one exception being the Dilemmas Based DM system [21]. This Drama Manager works by creating dilemmas for the characters between a set of actions that can be classified in four different types. It has all the features we are aiming to achieve, but in terms of narrative it borrows heavily from the Hero's Journey theory and thus does not explore many different story structures.

This is where this work differs from the previous ones. We would like to propose a system that will allow for authorial control and complexity of narrative as well as the adaptability and replayability. We will use as base for our method the narrative theory proposed by Durand [7], which will widen the possibilities of story structures generated by our DM.

IV. Methodology

As previously explained, in interactive storytelling, the narrative can be represented as a graph, where the nodes are plot points and the edges the conditions to move from one plot point to another. In an adaptive narrative, instead of presenting all nodes to the user we can present only a subset of them to direct the narrative, chosen according to the players preferences. The work of choosing which nodes to show to each player according to his/her characteristics is the job of the drama manager (DM).

The DM makes its choices according to the player preferences, expressed by a player model (PM). Here we model the user preferences and the dynamics of the narrative using Durand's three regiments of the imaginary, and the DM makes its decision based on the user preferences regarding these regiments.

Each choice the player makes in the game updates the PM. The PM guides the flow of the plot points using the player profile - which is updated in real-time so we can offer to the player more adaptability in the story. Given a game projected in m phases, after the player finishes a plot point, the DM runs and selects which plot points, or quests as it will be referred to from now on, to offer them for the next level. Each phase is composed of the one quest that the player will pick from the set selected by the DM as exemplified by Figure 3. The next sections present in detail the proposed PM and DM.

A. The Player Model

As stated by Laurel [23], by modeling the player behaviour and using this model to limit their experience, the system manipulates the player in an obvious and inefficient way. To counter this point, this work uses a minimal player model that does not intend to classify the player into categories or to predict player behaviour. The purpose of the PM is to guide the aesthetic experience a player is seeking out in the game from time to time.

The proposed player model is a simple vector of three dimensions, where each dimension represents one of Durand's three regiments of the imaginary, namely diurnal, synthetic and nocturnal. The PM models the player by understanding which alignments they is favouring in their actions and to which extent. Note that the PM does not attempt to classify the player in one of the three regiments, but to understand how the player relates to each of them. The PM serves as a reference point of the narrative arc a player is experiencing, and of how their actions reflect the type of story that is being developed.

In the same way that players are associated to 3-dimensional vectors corresponding to the tree regiments of the imaginary, so is each action of the game. In other words, the game author decides how much of each of the regiments is represented by an action.

The game begins with the player model vector set to zero on the three dimensions. As the player chooses actions throughout the game, this vector is updated by a function that takes into consideration the weight vector for the action selected. In the update method, the weight of each of the regiments on the player model is updated using a weighted average between the current value of the vector and the weight of the action vector. This average is weighted because the action vector is rescaled by a value α, which will define how much influence the actions will have on the player model. Here α is set to 0.05.

The regular updates of the PM ensure that the model reflects current player actions, and does not allow the player to be trapped into one kind of experience as soon as they make their first choices. In this way, the PM is used by the DM to adapt the story to something that caters to the current player behaviour, while maintaining the overall cohesion of the story.

B. The Drama Manager

The Drama Manager module (DM) is responsible for deciding which quests will be presented to the players, and it is triggered at the start of each level of the game. It is based on a genetic algorithm (GA) [24], used to select from a quest pool the subset that should be presented to the player at each phase.

A GA is a search method from the field of evolutionary algorithms, and is based on Darwin's ideas of evolution and survival of the fittest. In GAs, a population of individuals – where each individual represents a solution to the problem being tackled — is evolved for a set of generations, as depicted in Figure 4. Evolution occurs through the selection of the individuals that are more appropriate to solve the problem, quantitatively measured using a fitness function. Selected individuals undergo crossover and mutation operations according to user-defined probabilities, and a new population is generated. This process is repeated until a stopping criterion is met, which is usually a pre-defined number of generations.

In the DM, given a set of n quests, an individual represents a subset of these quests that should be presented to a player associated to a given PM in the current level. These subsets of quests (individual sizes) may vary from 2 to $n-1$.

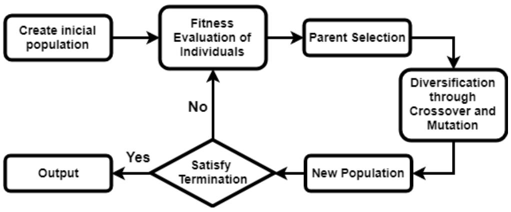

Figure 4. The general flow of a Genetic Algorithm

The initial population is generated by randomly picking a set of quests from the available pool. In this first population, we have an uniformly distributed number of individuals of different sizes. The next step is the fitness calculation.

Fitness: As previously mentioned, individuals are evaluated according to their appropriateness to solve the problem using a fitness function. In our case, the fitness indicates how relevant to the player, according to its player model, is the set of quests presented in each phase of the game.

Both the player model and each of the quests in the individuals are represented by vectors showing the preferences of the user/action to the three regiments of Durand's imaginary. The fitness of the individual accounts for the affinity of the quest set with the player model, and adds an onus to counter very small sets of quests, which may compromise replayability. The GA minimizes the fitness.

The affinity is given by the average of the difference of the 3 dimension between the individual and the player model. This difference is calculated considering the mean of the distances between the s quests that define the size of an individual and the player regiments, as showed in the first part of Eq. 1, where I represents the vector of the individual being evaluated and P vector of the target player.

$$fitness = \frac{\sum_{i=1}^{s}\sum_{j=1}^{3}(I_{ij} - P_j))}{3s} \times max(1, l - size(I))^3 \tag{1}$$

The similarity can be modified if the size of the individual, i.e., the number of selected quests, is smaller than a predefined threshold l. This is important because we want to guarantee a minimum number of choices is given to the player. The onus is calculated by choosing the maximum value between 1 and the difference between the chosen threshold and the individual size. Hence, the smaller the individual regarding the threshold, the bigger the penalty it receives. The affinity is then multiplied by the onus by the power of 3, a constant used to control the influence of this onus on the fitness.

Genetic operators: After the fitness calculation, a probabilistic tournament selection is performed. This method randomly selects k individuals from a population, and the tournament winner is the one with the best fitness value, and is the selected individual. Selected individuals are then submitted to crossover and mutation operations.

Crossover involves two individuals, and its idea is to exchange genetic material between them. We use a one point crossover, where a point in the vector representing the subset of quests is randomly selected in both parents. Following, the first part of the vector of one individual, limited by the selected point, is merged with the second part of the second individual. In the same way, the other two halves of the individuals are put together.

Note that crossover can happen between individual of different sizes, but the individuals generated during this process must respect a maximum individual size. If the size of the new individual is greater than this limit, the quests after the limit are simply ignored and removed from the new individual. A problem that needs to be addressed when performing crossover is when a quest appears in both halves of the parents being combined. In this case, a quest that is not on both parents and that has not been added yet is picked from the other parent.

In contrast with crossover, mutation involves a single individual and can happen in three different forms: by adding, removing or replacing a quest of the selected individual. Mutation by addition adds a new randomly selected quest to the individual, while mutation removes a randomly selected quest. Mutation by replacement changes a randomly selected quest to another not present in the current individual.

The choice of which type of mutation should be performed is uniform. However, individuals that are smaller than 3 are always directed to mutation by addition of quests and individuals that are equal or bigger than $n-2$ (where n is the total number of quests) are always directed to mutation by quest removal.

V. Experimental Analyses

The experiments performed to evaluate the proposed method were divided in two parts: a quantitative and a qualitative one. On the quantitative part, we investigate the algorithm's ability to adapt to each of the regiments and observe how diverse the stories being generated are in order to check the possibility of replayability. On the qualitative part of the evaluation, real players played a game prototype with a plot developed by game designers. This part of the evaluation focuses on how well the DM adapts the story to the players, how much player autonomy the DM allows for and how the stories created relate to the authorial control of the game designer.

Before starting the evaluation, we performed a set of experiments to set up the parameter of the GA, which are the population size, number of generations, probability of crossover and mutation, and tournament size. After preliminary experiments, we set the mutation rate to 0.4, the crossover rate to 0.6. Different tests run with different number of individuals and generations as well as tournament sizes, which are detailed later.

A. Quantitative Experiments

For the quantitative experiments, we first generated an artificial plot story to test the DM and set the parameters of the genetic algorithm. The quests that compose each plot were created using two different approaches: random and biased. The random approach assigned random weights to each of the three regiments (diurnal, synthetic and nocturnal) that describe a quest. The biased approach generated three clusters, and assigned a higher weight to a predefined regiment in each cluster. In this way, each quest was biased to a specific regiment. Thus, we have two different plots (with empty quests): the first with random weights, and the second privileging one of the three regiments in each quest in equal sizes of quest sets. Each dataset has a set of 300 quests. We also generated datasets with smaller number of quests, and for these datasets we compared the result of the GA with the optimal set of quests to be presented to a user.

We start by performing a comparison of the proposed DM with an optimum (exact) solution to select quests. The exact solution generates all possible combinations for the quests, and then calculates the distance between them and the player model. It then sorts these candidate sets and picks the closest. We compared the datasets created by both the random generated quests as well as the quests that leaned more heavily to one of the regiments. In this comparison, we start with small sets of quests and they grow it with a maximum runtime of 90 minutes. For 22 quests, which allows for a total of 4,194,281 combinations, the maximum runtime was reached and no solution found. Figure 5 shows the runtime for number of quests we found the optimum solution in the defined computational budget. Note that the number of quests is not a limitation for the GA.

The results of this first comparison are reported in Table II, where we show the results of the distance between both the optimum solution and the GA-based varying the number of quests from 18 to 21. We also present the number of possible combinations (column # of Comb.) of quests and the size of the best solution found. Note that the size of the best quest combination is equals to 2, and for that reason, for different sizes of quests, it remains the same. We observe that the optimum solution found a set of quests that is closer to the PM, but it did so by narrowing down to a very small set of quests, limiting the player experience and not allowing him/her to explore much outside of his/her current profile. Even penalizing smaller solutions, the DM arrived at quest sets which have a fitness that is not very far from the one found by the exact solution. The DM is capable of adapting to a PM and picking larger sets of quests, favoring adaptability but also not limiting player choice to only a couple of plot points. The adaptability is further explored on the qualitative tests later on. The results obtained with the random dataset are very similar to those presented in Table II, and are omitted in this paper.

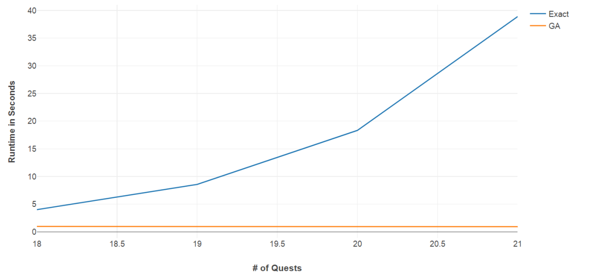

Figure 5. Runtime comparison between the exact method and the GA.

Table II. Distance to the model player considering the Optimum solution vs the GA-based using the biased set of quests.

# of quests	# of Comb.	Optimum		GA	
		Dist. to PM	Size	Dist. to PM	Size
18	262.125	0.1548	2	0.3027	7
19	524.268	0.1548	2	0.2880	6
20	1048.555	0.1548	2	0.2843	3
21	2097.130	0.1548	2	0.2543	4

The idea of this experiment was to analyze the adaptability of the DM as well as the potential of replayability this method can introduce into a game. The adaptability can be observed in the GA's ability to arrive at better quest sets for the player, which can be tested to an extent on the artificial tests. To understand the replayability of the subsets of quests generated, a measure of diversity of the selected quests in the final population was proposed. As suggested quests sets may have different sizes, given two individuals I_A and I_B, we first calculate how many of the quests are present in the subset represented by the two individuals. We then normalize this value by the size of the individual and average it, obtaining the value of similarity between two individuals. We then subtract it from one, as shown in Eq. 2.

$$diversity = 1 - (abs(\frac{I_A \cap I_B}{size(I_A)} + \frac{I_A \cap I_B}{size(I_B)})/2) \qquad (2)$$

When looking at the quests selected by both methods, the optimum solution involved quests with ids 13 and 14. Quest 13 was included in all solutions found by the GA. For the solutions of size 18 and 19, the returned solution contained the optimum set. However, note that the fitness of the GA has a penalty for solutions that are too small. For the artificial datasets, we set this value to 5. Hence, even if the GA found this solution at some point, its fitness was penalized because of its size. Having a very small set of options to the player reduces replayability, which is not desirable in the proposed DM.

These results also show that the non-deterministic nature of the DM allows for different experiences even when the play style of the user varies only minimally, Which is something that does not happen with an exact solution.

After this first comparison, we set the size of the quest set to 300 to simulate a large search space and performed

Table III. Parameters and results of fitness for the DM in the synthetic datasets.

Parameters		
Dataset	Biased	Random
Number of Generations	150	150
Population Size	3000	3000
Tournament Size	10	10
Results		
Dataset	Biased	Random
Mean Fitness	0.0069	0.0058
Median Fitness	0.0575	0.04907
Diversity in solutions	82,38%	84,16%

a set of experiments to tune the parameters of the GA. Table III shows the final parameters and the solutions found considering an average of five executions. The algorithm was also tested with the random dataset, reaching similar results. Note that the diversity of solutions in the biased dataset is as high as 82.38 % in the initial population, and 84.16 % for the random dataset, which indicates the potential for a high replayability in both situations.

B. *Qualitative Tests*

While the quantitative tests were interesting to evaluate replayability and map out the DM behaviour for stories with larger sets of quests, in order to understand how the proposed method will translate into player experience it is necessary to conduct qualitative tests with real players.

The qualitative tests were conducted through a text-based prototype of a game utilizing the DM to guide the narrative. The prototype used for the tests was a text-based adventure game where the players can read on the screen what is happening and then chose how the protagonist will do next. The game was divided into 5 levels, the first one composed of three quests that are always available at the start. In one complete run a player plays 5 quests, one per level. The initial level is used to create the first player model. After playing the first level the DM runs for the first time and picks a set of quests for level 2 for the player to choose from. At the start of each level the DM runs and choses which quests will be available for them to pick and the player plays only one quest per level. Each of the levels from 4 to 5 had 12 different possible quests for the DM to choose from. During this phase, the GA was run with 100 individuals evolved for 100 generations and tournament size 10.

The group of participants chosen for this experiment were people in undergrad or grad school, with ages varying from 19 to 28 years old and there were two women and nine men. The participants had varying levels of engagement in games, with people who had never played games to hardcore gamers. The eleven participants played the game and then answered an interview about their experience with the story. The prototype also produces a log of the player alignment at the beginning of each level and lists the quests the DM chose for them as well as the quests played by the participant. The interviews were coded to identify how much of their experiences related to each of the regiments, as well as to map out their perception of agency in the game and their identification with the story created. The interviews were then compared with the logs and analyzed to understand how perceivably limiting the DM was, how well fitted the narratives were and to check the perceived consistency of the stories created.

The method used to analyze the interviews was to read through the transcripts and identify points that appeared more than once in the same interview or that related to the three regiments of the imaginary used to create the Player Model. After the first read, the interviews were coded as they were read more closely. Those first codes were the ones that emerged during the second read, tagging ideas and images that appeared on the interviews. From the codes of the second read, five themes were created, three related to the regimes of the imaginary and two considering the narrative experience. The five themes used on this were: (i) diurnal, (ii) synthetic, (iii) nocturnal, (iv) identification, (v) break. They were then used to code the interview during another read of the transcripts. During this process notes were taken, comparing the codes with the player logs produced by the algorithm during each of the participant runs.

1) Interview Results: This section highlights three of the results found on the interviews: the conformity with the regiment images, the identification created by the DM and the non-limitation of the method. Identification in this context relates to the adaptability feature. This is used to highlight in the interviews moments the participants identified with the story they were playing or with the protagonist of the story. And non-limitation relates to player autonomy. The participant that expresses not feeling limited by the DM, being able to do as they wanted, and overall not being very aware of the action of the DM, is a participant that has player autonomy.

We found in the interviews that the perception the players had of their narratives match with the images belonging to the regiments assigned to their profiles by the algorithm. Images pertinent to their major regiments tend to appear in repetition throughout the interviews. We also observed that the moments the participants bring attention to as moments they enjoyed most were in the vast majority moments defined by their dominant regiments. This result shows that the adaptation feature was addressed and that the use of Durand's imaginary can be identified on the experiences.

One example of this type of behaviour is with participant 7, P7, which scored high on the diurnal regiment on every level. During his interview P7 focused on diurnal images which confirm the judgment made by the DM. The diurnal regiment is composed of schizoid images, it is obsessed with symmetric structures and in the opposition of sides. For Durand the core of the diurnal regiment is this drive against the dark and the evil, and against the symbols that compose its semantics [7]. P7 created his experience in the game in an effort to be on the good side. He explains his way of interaction in the interview as follows:

> (...) the notion of right and wrong, good and evil, on the beginning its not... its not so clear, you know? Its still being built and... because I didnt have the background of the characters I didnt know... I had to explore their personalities. So I was a bit in the middle of the road to see... until its well defined. Because I dont want to fall on the role of the villain. Thats the path I dont wanna take. So Id rather they get a bit clearer before I take one of the paths.

P7 talks about waiting until he knew which characters were villains and which were heros so he would side with the good side. His protagonist is the diurnal hero Gasi [9] explains in her thesis, an ascentional hero with a clear and final view of good and evil.

Another point that brings up an effective adaptation is the identification feature. The identification was coded when the participants expressed that the story was coherent with their actions, when they showed that they enjoyed the storied lived better than the other versions that could be showed by the DM and were presented to them during the interview, or when the participants talked about the protagonist in the first person. We observed in the interviews that the participants expressed identification with the story and felt the narrative to be coherent. There is a preference for the stories they lived over the other possible stories the DM hid from them as can be observed from the interview excerpts bellow.

> I think it would really make more sense... this battle thing. Because I was playing a more aggressive game so it would be very out of the blue this ”Oh now were gonna drink some tea” (She makes a mocking voice and laughs) It really wouldnt make sense. -P0 about the other story options that she did not see.

> But at the same time she has a very loving side, which I dont know if its something of me that I passed on to her of if its hers, cause(sic) its a bit confusing, isnt it? I am her. (He pauses and smiles) -P2 talking about his perception of the protagonist.

> I was frankly afraid (...), but I had the feeling if you defend the right things suddenly everything can... That you consider right... Suddenly everything can blow up and some shit can happen. I was particularly happy that it had a coherent flow. -P4 about the coherence of the narrative arc with the actions he was taking throughout the game.

Participants 0, 2 and 4 talked about how the stories they lived felt more valid and enjoyable than the ones excluded from the gameplay. In P0s case, she goes on to mock one of the excluded options of the opposing regiment. The participants also recognize a coherence in the narrative they lived and its conformity with their actions. In the case of P2 it occurs a deeper identification between the participant and the protagonist, which can be observed on the repeated use of the first person to talk about the character.

And finally, we wanted the DM not to be limiting to the players, that is for the players to have autonomy, which can also be observed in the interviews. It was possible to identify in most of the interviews statements from the participants that help understand how non-limiting the DM was to their experience. The sensation of limitation was not brought up, in fact the participants describe encountering some quests from slightly different branches from their own and deciding to avoid them in favour of following the stories more closely aligned with their profile. On the examples bellow we can observe some instance of this happening.

> Between Hugo and Rita. That he goes ”Theres something weird happening” and you say ”No, let it go, let it go everything is gonna figure itself out...”. - P5 about the conflicts she saw in the game.

> And also the fact that I didnt back Hugo up, and that I said ”Oh no. Dont you drag me into this. I dont wanna hear about it.”. And I dont know, I didnt know if following him on that matter Id have any voice and youd have many options inside there. So I said ”Ah for the better I dont wanna back this shit up.”. -P4 talking about the conflict between humans and monsters.

In these instances we can see moments where the players found narrative threads that were different from their own profiles and decided against taking them in order to follow something more aligned with the Regiment they more closely relate to. At the same time, there is the active approach to this issue. Instead of looking at moments the participants rejected different story options the non-limitation, or player agency, we can observe when the participants state their way of interaction with the game and that matches the narrative produced as observed on P5’s quote bellow.

> The choices I made were made more on the sense of getting closer to people and helping people. And I was feeling that through the story, I was really closer to people. -P5 talking about how she approached the game choices.

These results will be further explored in future works. However, it is important to point out that the DM was analysed in different ways to account for the desired features that were listed at the beginning of this paper.

VI. Conclusion and Future Work

The proposed genetic-based Drama Manager inspired by Durand’s theory allowed for the creation of a method that can adapt to player's preferences in a nuanced manner. As detailed before, a set of four features were kept in mind during the development of this method, and throughout the tests it was possible to identify some of these features in action. The replayability feature was observed in the tests with artificial quests, which showed a high diversity in solutions. The adaptation is also accounted for in the artificial quests test. During the tests against an exact solution it was possible to see that the method runs in a timely fashion and can be used in a game without drawing attention to its presence. It also consistently presented the player with a bigger set of quests to chose from, which increases Player Autonomy.

Even on a purely quantitative examination it is possible to see that the use of the genetic algorithm inspired by Durand's theory is a viable possibility to be explored in the field of Adaptive Narratives. By stepping away from a firmly defined structure of story and allowing a non-deterministic technique to guide the adaptation it was possible to create a DM that can adapt to a greater variety of preferences.

However, in order to address Authorial Control and to deepen our understanding of the other three features it is necessary to move to qualitative tests. As detailed on Section VI.B an initial set of these tests were conducted, and will be further explored on future works.

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