Content generation for turn-based strategy games

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ABSTRACT

Turn-based strategy games require generating a large number of game levels. This paper presents a solution that is able to address the problem of generating new content for turn-based strategy games according to the player experience and behavior. To achieve this we defined a system that models the player personality and is responsible for managing a pool of valid content and assessing its quality regarding the adaptivity to a player and the conformity to specified objectives. This approach is based on the concept of play-persona to capture the user profile in order to select the best game levels that may give the best experience. The proposed solution was adapted to the game Strategy War with very satisfying results. The game has the possibility of generating infinite game levels and the ability to select them according to a more defensive or aggressive profile.

Categories and Subject Descriptors

I.3.5 [**Computer Graphics**]: Computational Geometry and Object Modeling—*Modeling packages, Geometric algorithms, languages, and systems*

General Terms

Digital Games, Procedural Content Generation, Turn-based strategy games

1. INTRODUCTION

The broad diversity of player's profiles and age creates difficulties in adapting game levels to all the players and the large costs associated to the creation of a large number of game levels have an impact on the budgets. Therefore it becomes important to develop solutions that allow procedural level generation in a valid and efficient way.

Turn-based strategy games rely on cognitive skills to allocate resources effectively and anticipate the moves that maximize the overall goals that lead to victory. The flow of the player throughout the game is very much dependent on the initial level layout and resources allocation. To maximize the experience for different player profiles it is therefore necessary to generate different initial conditions.

This work consists of providing the player with content that fits the game setting, it is valid for the underlying game engine, maintains a suitable level of difficulty, complies with guidelines of entertainment value and is able to achieve a set of behavioral responses and changes that fulfill the designer objectives. All of this requires an high level of personalization and tuning that is very hard to achieve (with an acceptable degree of usefulness) by traditional design and development methodologies. We thus propose a procedural content generation method that performs automatic, algorithmic-driven content creation.

Next section presents some related work and in section 3 a generic solution is described. Section 4 presents the results obtained from applying the proposed solution to a turn-based strategy game called Strategy War. Finally, some conclusions and future work are presented.

2. RELATED WORK

The problem of creating a system that is able to effectively capture the player state in a meaningful way has been receiving considerable attention from the scientific community and multiple solutions have been studied. Using the division presented in [1], experience modeling can be carried out in three different ways: subjectively, through the use of questionnaires filled by the players after the experience; objectively, resorting to apparatus for measuring physical reactions, that interpret a wide range of signals and try to determine what the player is feeling, placing him on one of a finite set of defined emotions; and, finally, using a game-play analysis' based approach that relies solely on game events.

While many works were done in each of the modeling types, we adopted the concept of Play-Persona [2], which focuses on how can we create a model that functions as a true representation of the player and how it can be achieved exclusively through in-game data collection. This relates to how the design and development of a game affects its interaction with the player, how can we identify and characterize interaction dimensions (Paradigms), how they translate to behavior spectra (Play-styles), how can these be measured (Play-metrics) and how can they be used to generate meaningful information about the player personality (Play-Personas).

Game experience perception was explored by several authors [4] that presented various perspectives on what makes games fun. The most relevant concept was that learning potential is one of the main ways to enhance fun [3].

Other works relate to how procedural content generation can be applied with success to a player-centric adaptation approach [1], and how can procedural generation be characterized in various dimensions and what are their advantages, disadvantages and recommended uses [5].

3. CONTENT GENERATION

In order to develop a system that is able to model the player personality, create a pool of available content that will be analyzed, and evaluate it to assess its quality regarding the adaptivity to a certain player, it is necessary to devise a structure that covers all the processes involved. With this in mind, we propose a generic solution composed by three main components that will work on separate time-frames: modeling, generation and evaluation.

3.1 Modeling

This module aims to create an accurate model of the player, both skill and personality wise. This joint approach marks a shift from the way these behavioral aspects have been separately handled. As mentioned before, the personality modeling is based on Canossa's work [2], namely by the use of concepts like play-styles, paradigms and play-personas that are improved by the use of more complex and precise definitions, the application to a specific use case and the exploration of associated problems and precautions that must be taken into account when trying to perceive how a player behaves. The first thing to realize is that personality modeling is highly dependent on the genre and on the specific game. This problem creates the need to perform a detailed analysis of the virtual world in which the player operates, the tools provided to interact with it, how they behave relatively to each other and what sort of dynamics originate from it.

Game paradigms represent areas of potential behavioral demonstration, segmented by the type of interaction, that define what possibilities of expression are available through the choices presented to the player. Play-styles are defined for each paradigm existent in the game and they aim to provide a low-level representation of a certain behavior that is part of that paradigm. Their representation consists of a value in a spectrum (range) that measures its conformity degree. The spectrum's extremes need to have a concrete meaning and to be completely opposite. A wide play-style spectrum represents makes it more difficult to take a decision. This in turn indicates its higher importance to a correct determination of the player personality. This follows the sub-personality approach explored by Canossa [2] but acknowledges the importance of the decision taken versus the amount of decisions that could have been taken. For each defined play-style, a local value will be determined by the comparison of game states, and their values will be assembled, with a relative weight, to a global play-style value. If there is not enough information to determine the player behavior in some play-style, its value should be a unique one that will be ignored in the assembly stage.

After the specification of what play-styles are to be evaluated and their meaning, it is then necessary to know how to evaluate them. As the proposed methodology follows a gameplay-based player experience modeling [1] it is necessary to determine what game variables and events need to be collected to calculate the play-styles. This collection is done through a layer that is placed on top of the game engine and that is responsible for the extraction and dispatch of necessary data to the modeler.

The final step in player modeling consists on the specification of Play-Personas. Play-personas are a set of representations of possible stereotypical behaviors, suitable of being demonstrated in the game. They are defined as intersections of values for each of the play-styles. These can be specified by the use of theoretical models based on assumptions and designer intuitions, that can be further expanded or modified by empirical analysis of collected game-play data. A Play-persona is a vector of values with the same number of elements as the amount of play-styles, each corresponding to the desired value of the play-style (or a negative value if that play-style is irrelevant to that play-persona).

In spite of being a very promising way of capturing the player experience, this kind of modeling has a number of associated problems, mainly derived by the game on which it is applied. In particular, every game has goals or a set of desired states that the player aims to achieve. This implies an analytical deconstruction of the game environment, in order to compare the usefulness of the various choices present and the assessment of their relative value, which is not trivial.

3.2 Generation

The generation stage is responsible for the automatic creation of content. First of all it is imperative to define what kind of content to generate so that it is able to provoke the desired behavioral responses on the player. As this methodology was defined with a turn-based strategy game in mind, the kind of content chosen to be generated were game maps. The generation method was based on "generate-and-test" approach, situated in the middle of the online - offline spectrum [5]: levels are chosen in real time from a previously generated pool of levels.

The generation is bounded by a set of parameters that direct the results towards a set of desired goals that meet some sort of restrictions or specifications. This may result in a reduced (preferably none) amount of undesirable content. In short, content generation needs to follow three rules: generate only valid content that is accepted by the game engine; follow some high-level objectives; strike a good balance between freedom and control. Given the nature of strategy maps, their generation follows a layered-approach. Each layer specifies an increasingly complex dimension that encapsulates the previous ones and adds some kind of layer-specific content and represents a different generation phase that has three inputs: general generation objectives, input parameters that serve as a limit of some kind for that layer content and a set of rules and restrictions that prohibit the layer from generating an intermediate non-valid piece of content.

Generated levels are then serialized and analyzed. The analysis is divided in the same layers as the generation and is responsible for the extraction of a set of features that are useful for the evaluation stage. Its values are normalized, to prevent the use of scale coefficients and to facilitate the comparison between different values and between the same values among different samples. After having a pool of generated content duly analyzed and a personality model of the target player, it is possible to provide him the level that is the best in following the desired objectives that take into account its adaptability to the subject at hand. Therefore there needs to be an evaluation phase that filters the levels that do not fit a set of restrictions,(like base difficulty and dimension for example), and evaluate the ones that remain, assigning them a real value that represents its compliance with the defined objectives for the evaluation.

3.3 Evaluation

The evaluation can be defined as a matrix that relates the Play-personas with content features. For each line (play-persona) and each column (feature) there is a real value (between -1.0 and 1.0) that is the weight that that play-persona gives to that feature when determining the quality of the content. The score given to a particular piece of content is calculated through a multiplication between the score that each play-persona gave by the probability of him being that play-persona.

The evaluation objectives define what we want to provoke on the player. One posssibility would be to reward levels that force the player to be positioned in an initial situation that tries to be the worst possible solution given its strategy. Another possibility would be to reward levels that make it easier for a player of that kind to expand and make it easier for him to win. This evaluation can be used to reward several aspects connected to good game design guidelines, like challenge, decisions, uncertainty and exploration.

Figure 1: The game Strategy War

4. RESULTS

The proposed solution was applied to a turn-based strategy game - Strategy War (developed by AppGeneration - figure 1). This game aims at conquering an hexagon-based world, where each player owns a set of hexagons where military units are allocated, and that can be used to defend or attack the adjacent regions of another player. During each turn the player can perform the following actions: buy unit, conquer hexagon, move units in his own territory, upgrade unit or give up.

There are two kinds of available units: offensive and defensive. Each unit has a protection zone that is comprised of all adjacent hexagons that belong to the player who owns the unit, and every unit is characterized by some attributes, one of them being its relative strength. To conquer one enemy hexagon one needs to use a unit that is stronger than the one that is protecting the target hexagon. Every player has a number of regions, each region being a set (more than one) of hexagons in adjacent positions. There is an economic perspective to be taken into account by the amount of money a region has and its profit/maintenance cost per turn. In each turn the player can take as many actions as his resources allow.

In spite of being a simple game, it is possible to extract three main game paradigms from it: *Expansion*, *Military management* and *Financial management*.

4.1 Play-styles

For each of the three paradigms it is possible to define a set of play-styles that define the player behavior in that domain.

For the expansion paradigm we define three play-styles:
Expansiveness (E) is the willingness of the player to expand. A maximum value represents a player who tries to expand wherever possible while a minimum value represents a more reserved player.
Expansion style (ES) represents the way the player expands by the calculation of the mean connectivity (figure 2) between conquered hexagons.
Attack style (AS) measures the aggressiveness of the player through the comparative analysis of conquered regions owner's power. An high value indicates a preference over attacking stronger available regions while a minimum value represents the opposite.

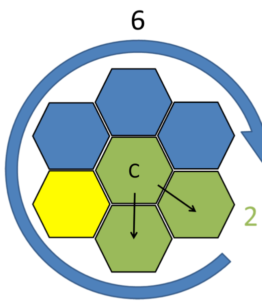

Figure 2: Connectivity value of an hexagon: As *C* is surrounded by 2 "friendly" hexes and 4 "enemy" hexes its connectivity value is 0.33.

Regarding Military management it is possible to distinguish three different play-styles:
The *Offensive army size (OAS)* relates the amount of offensive units that the player uses and the dimension of the territory that he controls.
The *Army type (AT)* characterizes the player's style, namely

if it is offensive or defensive, through the relation between the two types of units.
Territorial Protection (TP) determines the percentage of risk hexes (hexes in contact with enemy territory) that are not protected by any unit.

Financial management originated only one play-style, the financial risk (FR), that the player takes by comparing the total money between the final and the initial state.

Therefore every player has a personality model composed of 7 real values representing the 7 play-styles.

4.2 Play-personas

The Play-personas were determined by a analysis of several game sessions that were previously recorded through the use of hierarchical clustering algorithms on a population of 1974 games, using the seven play-styles. This led to the finding of two main clusters, whose information can be found in the following table:

E	ES	AS	OAS	AT	TP	FR	elements
0.84	0.43	0.78	0.63	0.92	0.34	0.84	1599
0.22	0.63	0.18	0.32	0.35	0.78	0.20	375

Through the analysis of the clusters, we can see that player average behavior falls on one of two extremes, an aggressive or a defensive one. This led to the specification of two complete-opposite Play-persona probability spectra. While this may seem an overly simple model, it was the most useful solution that could be extracted from the gathered data.

4.3 Generation

As previously mentioned, being a strategy game, the chosen type of content to be generated was game levels (hexagon world maps). The general objective was to generate balanced maps that would not put any player in a significantly unfair initial position. Each layer has a number of parameters that limit element-type-specific placement, and distribution properties and a set of rules and restrictions that prevent the generation of invalid intermediate content.

The structural generation follows a cycle of hexagon placement and expansion direction calculation which is determined semi-randomly based on compactness parameter and maximum radius to generate appropriate layouts which have to be possible to represent by a fully connected graph to be accepted by the game engine. The color filling stage is responsible for coloring the placed hexagons, each color representing its owner. This stage has to guarantee that every player has at least one region. Military and financial layers are responsible for unit placement and are bounded by input parameters' maximum probabilities and by maximum and minimum money per region.

4.4 Evaluation

The evaluation phase starts when a player requests a new level, thus causing an initial filtering of content. This is achieved by calculating the base difficulty, obtained by the average between initial and future pressure for each controllable avatar. Therefore, for each map there will be x score values, x being the number of controllable avatars in that map that pass the difficulty filter. The evaluation objective rewards maps that force a player to take a different stance than the one manifested through the personality modeling sessions. For an aggressive player the system will reward maps that force him to be more cautious and careful and for a defensive player the system will reward maps that encourage offensive approaches. By multiplying the Play-persona score by the probability of the player, being that Play-persona, and averaging the sum of all scores, it is then possible to achieve a final score that will dictate the content quality in the perspective of the evaluation objective.

Some tests were conducted and higher scored maps proved to be harder than low scored ones even in the same base difficulty range, which serves as an indicator of the usefulness of the proposed methodology. Even so, further testing is need to evaluate its quality.

5. CONCLUSIONS AND FUTURE WORK

This paper presents an approach that improves general game content quality for turn-based strategy games by modeling the player personality and generating game content that is evaluated to measure its adaptability to the player in conformity to the general objectives that are specified. The proposed methodology was applied to a specific game and the results were quite satisfactory. This solution is thus able to provide infinite game levels for turn-based strategy games, selected according to each player style.

There are still many explorations paths on how to convert good game design principles to a relation between play-personas and content features, and there are many improvements to be made on how to evolve the content pool through the use of evolutionary algorithms.

6. ACKNOWLEDGMENTS

This work is partially supported by the Portuguese government, through the National Foundation for Science and Technology - FCT (Fundação para a Ciência e a Tecnologia) and the European Union (COMPETE, QREN and FEDER) through the project PTDC/EIA-EIA/114868/2009 entitled "Eras - Expeditious Reconstruction of Virtual Cultural Heritage Sites". We would also like to acknowledge the collaboration of AppGeneration on the development of this work.

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