Wonderful Design: Applying Appraisal Theory to Procedural Level Generation

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Abstract

Procedural level generation for games is an active field of research with successful applications. However, how to generate content that embodies design intent is still an open research question. Level designers lack abstractions and tools for authoring generated artifacts for affecting emotion. We propose a novel pattern language for generative level design inspired by Appraisal Theory. Its patterns enable designers to add meaning, depth, and cohesiveness to the resulting content, and modify artifacts to make the content more engaging. We illustrate how these patterns can be implemented in a generative grammar for level generation for an adventure game. Formative evaluation of generated level content demonstrates the feasibility of the approach and suggests points for further improvements. Future work could focus on other elements which seem important for affecting emotions, including pacing, perception, and expectation.

Introduction

Procedural level generation is a kind of Procedural Content Generation (PCG) that helps level designers author game levels (Shaker et al. 2016). In this study, we focus on approaches to PCG that employ generative grammars. Instead of creating the levels by hand, designers author grammar rules that transform level artifacts step-by-step, generating a wide variety of playable environments, missions, quests and stories (e.g., see Dormans 2010; Karavolos et al. 2015). However, not all generated levels focus the attention and gameplay experiences in the way the designer intended, since it is difficult to control the generation of the situated content, e.g., in setting the stage for encounters and flow in landscapes that fit a story as it emerges. Moreover, abstractions and tools for designing and improving generated levels that evoke emotional responses are currently missing. As a result, generated levels are not guaranteed to represent the design intent, and regularly also contain noisy, distracting peculiarities that can break immersion. Design intent is understood to be the effect of the game as intended by the designer on the player's experience and affective state. We wish to learn how level designers can set the stage for grammar-based procedurally generated game levels, much like a director would for theatrical plays.

This paper assesses the feasibility of formulating a design pattern language for affecting emotions in level design and the implementation of those patterns in generative grammars for procedural level generation in order to help achieve this type of direction. Our approach is based on Appraisal Theory (Smith & Lazarus 1990; Ellsworth & Scherer 2003), which explains how emotions arise from appraisals made by people regarding their environment. The main research question we address is the following: How can Appraisal Theory be used to create design patterns for affecting emotions, and how can these be implemented using generative grammars for procedural level generation?

The assumption is that patterns for affecting emotions are able to make the content more engaging and contribute to a more coherent player experience. The research is carried out in the context of a commercial adventure game currently in development, which relies on advanced content generation. The approach presented here is meant to be general enough to be applied to level generation for other adventure games, in particular methods that incorporate generative grammars. Ultimately, the goal is to enable the discipline of level director who orchestrates the level generation process and affects related dramatic aspects for improving the overall perceived quality and player experience.

Related Work

Generating content that embodies game design intent is a key open research challenge. Here we relate our work to conceptual frameworks, techniques for PCG, design pattern languages, and emotional modeling.

Proceduralist readings is a framework that connects game elements, mechanisms and dynamics, and explicitly formulates rhetorial arguments in a thematic and cultural setting from which meaning is derived (Treanor et al. 2011). We model gameplay assumptions explicitly too, but instead focus on emotional effects as guided likely outcomes of an appraisal of interacting with generated content.

Procedural Level Generation

Procedural content generation can be employed for various reasons, including generating variations for increased replayability, saving time for the designer by automating the design process, gaining a better understanding of the creative processes in design, etc. (Togelius et al. 2013).

Although we understand that each of these goals may be important in specific game development or research contexts, we believe that for successful game development, the quality and coherence of the generated results is critical. PCG allows game developers to create an experience where players cannot rely on previous experience with the same content, creating an experience that is different from games where all levels are pre-designed. But this works best when certain standards are met in the generated levels (Rozen & Heijn 2018). As is the case with mixed-initiative approaches to PCG (Smith et al. 2011; Karavolos et al. 2015), we are interested in how PCG can change and improve the process of game development when concrete design knowledge, in this case the application of Appraisal Theory, is codified in the generative process.

Modelling Emotions

Theories on emotional process include categorical (Ekman 1992), dimensional (Plutchik 2001), and appraisal theories (Ellsworth & Scherer 2003). Appraisal Theory seems well-suited to our goals due to its ability to explain underlying causes of emotions while other theories mainly focus on categorization of emotions. Also, sources on emotions in games mention Appraisal Theory as basis to understand how to affect emotions (Yannakakis & Paiva 2014).

Appraisal Theory states that "…people's emotions arise from their perceptions of their circumstances – immediate, imagined, or remembered" (Ellsworth & Scherer, 2003, p. 572). A certain event, in relation to the one involved, is evaluated or *appraised* leading to an emotion (Smith & Lazarus, 1990). The different possible appraisals one can make have been classified in the appraisal dimensions (Ellsworth & Scherer 2003). Each of these dimensions is appraised separately, resulting in a specific value for the dimension, i.e., an appraisal. An example of such a dimension is *Novelty*, which can be appraised as high or low or everything in between. A specific set of values for each dimension then leads to a specific emotion.

Design patterns

Design patterns were first introduced by architect Alexander et al. (1977) as a formal description of a problem-solution pair. Since then, many design pattern languages arose, addressing different problems. Björk and Holopainen (2004) define a catalogue of abstract gameplay interaction patterns that describe how components are used by a player to affect the gameplay outcome. Zagal et al. (2007) take an ontological approach that describes and relates hierarchies of concepts and intents to weak and strong examples. These descriptive approaches are suitable for analyzing, critiquing and understanding games, but they do not prescribe how to modify and engineer a game prototype.

Adams and Dormans (2012) describe conceptual game-economic mechanics patterns that define how resources flow through a system, and patterns to engineer gameplay, e.g., choice, trade-off, friction, mitigation. Van Rozen (2015) describes a mechanics design assistant that leverages these patterns for live programming of game economies by generating them into running games.

Our pattern language represents a new category that introduces applied Appraisal Theory to create high-level emotional patterns and low-level appraisal patterns that steer the content generation towards structures we relate to desired emotional effects.

Design Patterns for Emotional Effect

Following the approach of design patterns, combining elements from different design pattern templates and approaches (Bacher 2008; Björk & Holopainen 2003; Gamma et al. 1995; Hullet & Whitehead 2010; Lemay 2007; Will 2013), we propose a template format for design patterns specifically for emotions and appraisals, consisting of the fields listed in table 1 and table 2, respectively. Next, we present examples of both kind of patterns.

Appraisal Patterns: Centering

Appraisal patterns support the emotion patterns by describing how to use composition, structure and meaningful objects in abstract solutions to realize the relevant appraisals. Patterns currently formulated within the language are *Centering*, *Pointing Out*, *Appearance of Objects*, *Frame by Surrounding*, *Content Density*, *Symmetry*, *Just Not Symmetric*, *Rewards*, *Rare Sightseeing* and *Conflict*. The *Centering* pattern is presented in Table 3 as an example.

Patterns for Emotions: Fear and Wonder

Based on Appraisal Theory, specific emotions arise from a specific set of appraisals. Therefore, by combining multiple patterns for appraisal, a pattern for emotion can be applied. For example, in Table 4, the design pattern for the emotion *Wonder* is presented. The solution part of this pattern,

depicted in Figure 1, shows the required appraisals (*Novelty*, *Pleasantness* and the negation *!Urgency*), together with potential ways to realize these appraisals in a particular form. The appraisal *Novelty* can be realized, for example, by *Centering* or *Pointing Out* the novel object, or by *Frame by Surrounding*.

Table 1. Design pattern template for Emotion patterns.

Field	Description
Name	A descriptive name with which the pattern can be uniquely identified and referenced to.
Problem	The emotion to affect.
Core relational theme	The core of the emotion captured in one sentence.
Forces	The considerations that must be taken into account when implementing the solution.
Context	The circumstances and constraints of the situation in which the given problem occurs.
Participants	The different patterns involved in the application.
Required appraisals	The appraisal dimensions and their values required to affect the given emotion.
Solution	The possible combinations of appraisal patterns for each required appraisal, captured in a diagram as shown in Figure 1.
Related patterns	The relationships this pattern has with other patterns including the type of relationship.
Example	An example in which the pattern is applied within the game.

Table 2. Design pattern template for Appraisal patterns.

Field	Description
Name	A descriptive name with which the pattern can be uniquely identified and referenced to.
Illustration	The essence of the pattern captured in an illustration.
Problem	The appraisal to trigger.
Forces	The considerations that must be taken into account when implementing the solution.
Context	The circumstances and constraints of the situation in which the given problem occurs.
Participants	The different objects and their respective roles involved in the application.
Affected appraisals	The appraisal dimensions and their values affected by this pattern.
Solution	The proposed solution for the given problem in the given context.
Related patterns	The relationships this pattern has with other patterns including the type of relationship.
Example	An example in which the pattern is applied within the game.
Variations	Multiple variations on the solution.
Inspiration	An overview of games, art works, etc. that inspired to capture this pattern.

Table 3. Design pattern for Centering.

Name. Centering

Problem. How to make an element of interest stand out in a level.

Forces. The element that should capture the attention has a particular *importance* or amount of focus, such that it stands out while all other objects are not completely overlooked. The more *diegetic* the way of drawing attention is, the better it fits the experience. The *size* of the element is important, since it can be hard to make small elements stand out. The *surroundings* influence the ease at which something can be made stand out and its resulting effect. Patterns triggering novelty *inhibit* emotion patterns that require the absence novelty.

Context. A particular object, group of objects or other applied pattern should capture the attention. A separated area pattern has been applied to the level, and the resulting area is large enough to consist of the object to capture attention and center things inside. Importance: the amount of focus this pattern can provide is medium to high, depending on the size and the surroundings. Diegetic: the implementation is diegetic but can be influenced by the surroundings. In some situations, it is not natural to center a specific element. Size: the size of the element of interest is at least medium and can be greater in relation to the other objects in the surroundings. Surroundings: the surroundings of the application of this pattern allow for centering by consisting of an area that stands out in such a way that it can be recognized as a separated area. All other forces are influenced by the surroundings.

Participants. Object of focus: the object, or group of objects, that captures the attention. Area: the available space, defined the applied separated area pattern, to place the object.

Affected appraisals. Novelty: medium – high

Solution. Place the object, or group of objects, to stand out in the center of the area created by the applied separated area pattern.

Relations. Requires a separated area pattern to create an area to focus in. Reinforces other novel objects patterns and rare sightseeing since applying those together results in a higher novelty. Extends symmetry, just not symmetric and rewarding resources since it adds novelty to the effect of those patterns.

Example. In the game currently under development, scrying points are a way of exploring the surrounding locations quickly. Such a point is indicated by a pillar-like object placed somewhere in the level. To make this object capture more attention and stand out, it can be centered within a frame. A variety of options can be used to create the frame: the area itself can be formed in a symmetric, basic shape, or a circle can be created with flowers.

Variations. Place the object on the edge of the area. Note that this is only possible if you can center on the form of the given area.

Inspirations. Metropolis – Ralph Koltai: The elevator – which rises into the city above in act I – is centered in the middle of the ground (Davis 2001, p. 36). The Ring Thing – Don't Starve: The Ring Thing is one of the 'things' the player needs to find to progress onto next worlds in Don't Starve. Each of these things are centered in a clearly identifiable, primitive form. The Ring Thing is centered in a circle with plants. This circle functions as frame and the Ring Thing could not be centered without it (Klei Entertainment 2013).

Table 4. Design pattern for the emotion Wonder.

Name. Wonder

Problem. How to evoke wonder in a given part of a level.

Core relational theme. Interest in the unusual or extraordinary.

Forces. Emotions can vary in *intensity*. A higher intensity will not only cause the emotion itself to be stronger but will also increase the number of different players actually experiencing the desired emotion.

Some emotions lose their impact when they are experienced more often. They are also experienced more fully when they are alternated with other emotions. One cannot experience joy forever for it would become the norm. Therefore, the amount of usages of patterns of emotions is correlated with the impact of it.

Context. The whole level or a particular part should give the player the sensation of wonder. Intensity: the intensity heavily depends on the selected low-level patterns and the application of those low-levels. To increase intensity further, low-level patterns affecting the same appraisal can be combined. Amount of usages: since wonder captures a feeling of surprise, an unusual feeling, the amount of usages should be limited and alternated with other emotions.

Participants. The selected appraisal patterns and their participants.

Required appraisals. Novelty: medium – high.

Pleasantness: medium – high.

Urgency: none – low.

Solution. See Figure 1.

Example. A moment of wonder can be created in the game under development by triggering all the listed appraisals. The player walks through the mountains when suddenly the pebble path changes in an old road with tile patterns, triggering novelty by appearance of objects. The surroundings are flattened and surrounded by pillars, which increases novelty with the use of the frame by surrounding pattern. Large statues of faces are artifacts of an ancient civilization and, although they spawn a number of times in a world, they are quite rare. One is placed in the center of the frame, which further increases novelty with the centering pattern, and adds pleasantness using the rare sightseeing pattern.

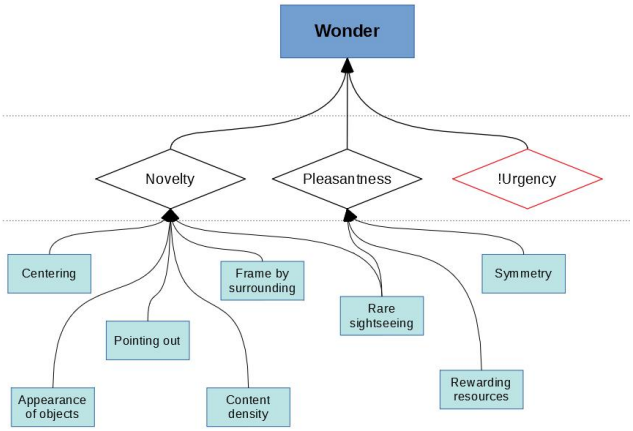

Figure 1. The solution part of the design pattern for Wonder, including appraisals and potential ways to realize them.

The appraisal *Pleasantness* can be realized using *Symmetry*, or by presenting a *Rare Sightseeing*, or by *Rewarding Resources*. To give an example of another emotion that has been formulated in our pattern language, *Fear* requires a different set of appraisals, including relatively high *Novelty*, *Urgency, Outcome probability, Conduciveness,* but no or low *Pleasantness, Adjustment* and *Power*, and *Agency* associated with other actors than the player.

Level Generation

As a proof-of-concept, a design pattern for emotional effect and its associated appraisal patterns have been implemented to generate appealing content in the form of levels for the game currently in development (The Sequel to Unexplored), using generative grammars in Ludoscope (Dormans 2011), which provides output to the Unity game engine. Although the emotion and appraisal design patterns are generic, the rewrite rules that place the patterns in the tile map are application dependent since specific structures and shapes are placed with specific tiles. The level generation process is depicted in Figure 2, in four steps, from top to bottom:

A. The patterns are placed in the graph, indicated by purple nodes, as is the participant, indicated by a yellow node. The blue edges indicate the order in which the patterns and participants must be resolved.
B. The patterns (and other features) are positioned and structured within the tile map, based on a recipe (an ordered set of rules) created from the graph.
C. After some intermediate steps, all non-terminal symbols are resolved to terminal symbols.
D. Unity interprets the level and places all objects accordingly, resulting in a graphical scene to be presented in the game.

Since the application of the *Wonder* pattern is a matter of combining low-level patterns that affect those appraisals, with only a few different low-level pattern implementations variations can easily be realized. For example, in Figure 2D, *Wonder* was realized by *Frame by Surrounding* (circle of objects) with *Rewarding Resources* (experience points) and *Centering* (scrying point in the middle of the frame), but the *Centering* and the *Frame by Surrounding* patterns could have been instantiated using other game objects, and instead of *Rewarding Resources*, other realizations of the *Pleasantness* appraisal could have been selected.

Some patterns are placed with one rule, such as the *Centering* pattern which only marks the center tile. Other patterns are placed with a sequence of rules that build up the pattern in a stepwise manner, such as the *Frame by*

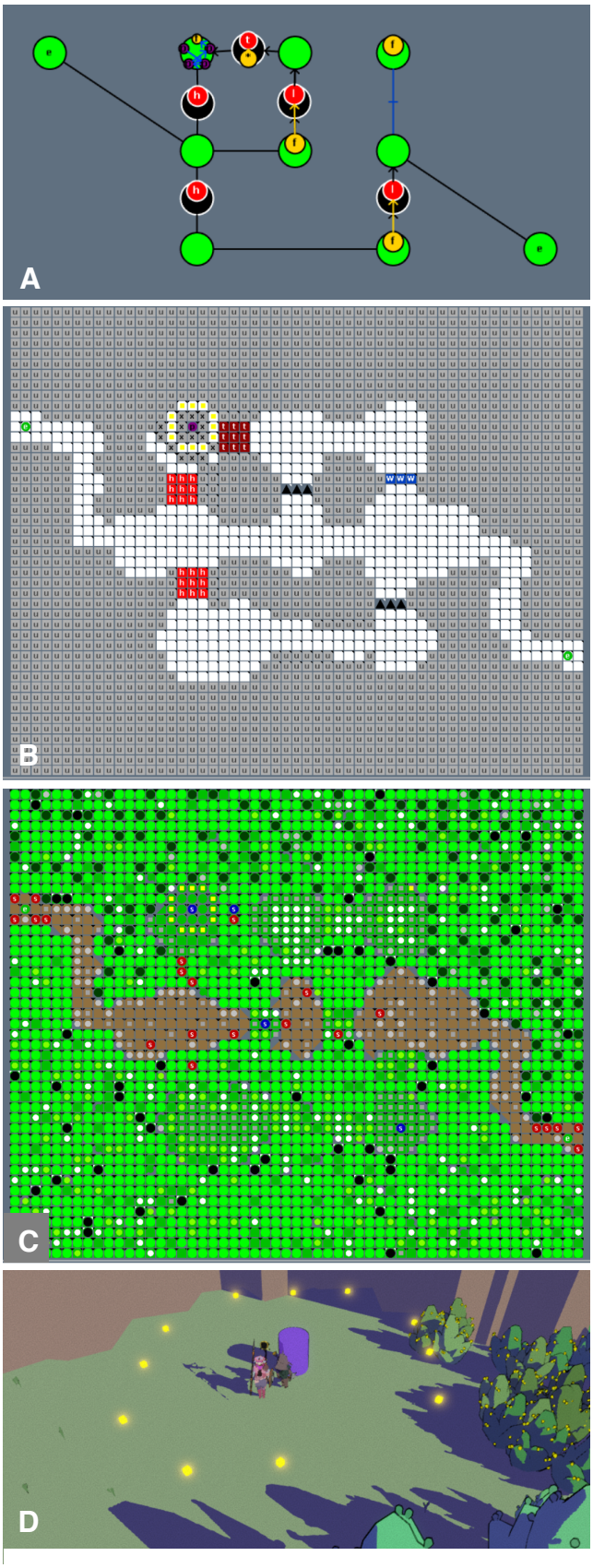

Figure 2. Level generation process, from A (top) to D (bottom).

Surrounding pattern. After a pattern is placed, interesting locations remain marked so participants can be placed later on.

Discussion

Generality and Scalability

Our approach is generic, but allows for domain- (i.e., game) specific extensions. The design patterns for emotions and appraisals can also be applied in procedural content generation for other games, or even other multimedia applications.

To cater for specific uses, users need to adapt the rules that specify how appraisals can be realized using elements of that particular game or application. When the elements are similar between games, the rules will be similar too. If other emotional effects are desired, new patterns can be added for those, without the need to change others. The appraisals for many emotions partly overlap, which means that the work done for these appraisals can be reused.

A content generation system that is able to achieve many different emotional effects, will need many rules, which increases its complexity and introduces new development and maintenance challenges. However, the specification of design intent in the design patterns makes the approach more modular and scalable than is often the case in procedural content generation systems; many rules will be variant implementations of basic appraisals, which in turn can be easily assembled into higher-level patterns. The modularity of the approach keeps the complexity under control, even when working with a large number of implemented patterns.

In addition, the design patterns facilitate a separation of concerns for the different responsibilities of a sophisticated content generator. The proposed patterns direct the implementation of high level design goals for individual levels or level sections. The responsibility for what those design goals might be can be placed elsewhere, either with a different expert algorithm, a human designer, or something as simple as randomly selected design goals.

Direction as Underspecified Situated Context

In our approach we use design patterns as a means to capture and express design intent explicitly. However, rather than specifying what needs to be generated, we view design intent as setting goals and necessary constraints, leaving ample room for unexpected variation in content and form.

We consider our approach analogous to the guidance given by a director in improvisational theater sports. In such a context, directions are typically not expressing what needs to be said or done directly, but rather the effect to be reached, or constraints to be taken into account. This leaves the result underspecified, which often leads to surprising outcomes. We view procedural content generation in a similar vein, not specifying directly what needs to be

generated, but rather the effect to be achieved, and multiple methods for achieving it, so that the results may still surprise the designer too.

Preliminary Evaluation

To assess whether the approach is feasible, the generated levels were evaluated in a meeting with three professionals from the game industry. The experts confirmed the value of the insights gained in this study, and that the implementation approach of patterns in generative grammars is valuable. Nevertheless, the implementation should be more prominent. Several promising improvements were suggested, e.g., applying multiple appraisal patterns per required appraisal or creating anticipations and expectations.
Additionally, the experts suggested that the current pattern language should be supplemented by taking into account elements that contribute to creating overarching experiences. Interesting elements to explore are the surroundings and the context of a pattern, the expectations and the anticipations of the player, pacing between emotion patterns and the perception of the game world. More thorough validation, and evaluation through playtesting is part of future work.

Limitations

Applying and extending and implementing the pattern language is work in progress. We identify the following bottlenecks and actionable steps:

- Recognizing shapes with variable sizes and consistency.
- Obtaining information about objects in the surroundings, such as the average color or size.
- Influencing the surroundings of a pattern.
- Providing sufficient variations and possible combinations of patterns to prevent recognizable repetition.

Future Work

Further work on the pattern language includes the addition of more emotion and appraisal patterns, and improving the implementation of patterns in generative grammars by addressing the limitations mentioned above. When the main implications have been identified and addressed, validation of the pattern language with more game design experts from research and industry is desired, as well as playtests with users to analyze the actual emotion effects, to further improve the language and the implementation of patterns.

Future research could focus on other elements that seem important for affecting emotions within the overarching experience of playing a game, such as pacing, perception, anticipation and expectation.

Conclusion

This study explored the feasibility of formulating design patterns for emotion in level design and the implementation of the resulting patterns in generative grammars for level generation. Using Appraisal Theory as a theoretical foundation, design patterns were presented for emotions such as fear and wonder, and their required appraisals, which describe how to use composition, structure and meaningful objects in abstract solutions.

According to Appraisal Theory, appraisals are made regarding the relationship between the event and the person involved and, together, they support the occurrence of an emotion. This theory depicts the structure of the presented pattern language in which appraisal patterns (triggering appraisals) are combined to apply emotion patterns (affecting emotions). An approach was proposed to implement such design patterns, expressing how rewrite rules can be created by increasingly adding features to and removing abstraction from the level, resulting in an applied pattern.

To prove the feasibility of implementing such patterns, a procedural level generator was implemented for a game currently in development, using an approach based on generative grammars. Preliminary evaluation with three experienced game designers has indicated that it is possible to create moments in which a given emotion is suggested. From a technical point of view, the use of the design patterns structures the content generator in such way that different concerns are handled by different components. This results in an architecture that is modular and scales well enough to accommodate the amount of content that is required for a commercial game.

The main contributions of this paper are (1) a new framework for capturing design intent as direction in grammar-based procedural level generation (2) the proposed pattern language for design patterns for emotions and the required appraisals, and (3) the implementation of a level generator that allows the game designer to play the role of a level director wishing to achieve emotional effects. These contributions are considered valuable for the research field of procedural generation of content for games and other interactive media. This is especially true when an approach is taken that involves design intentions, or when emotional effects are desired. The theoretical foundation of Appraisal Theory allows for logical design choices that allow extending the pattern language with other emotions.

Recommendations for future work include expanding the current set of patterns, addressing the limitations that were identified for the pattern implementation, validating the pattern language within a wider community of practitioners and researchers, and exploring the aspects in games that influence overarching experiences of emotional dynamics.

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