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A shape grammar approach to computational creativity and procedural content generation in massively multiplayer online role playing games

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ABSTRACT

With rapid growth in both production costs and player populations over the last decade, the computer games industry is facing new scalability challenges in game design and content generation. The application of computers to these tasks – called procedural content generation – has the potential to reduce the time, cost and labor required to produce games. A range of generative algorithms have so far been proposed for procedural content generation. However, automated game design requires not only the ability to generate content, but also the ability to judge and ensure the novelty, quality and cultural value of generated content. This includes factors such as the surprise-value of generated content as well as the usefulness of content in the context of a particular game design. Studies of human designers have identified that the ability to generate artefacts that are novel, surprising, useful and valuable are facets of the human cognitive capacity for creativity. This suggests that computational models of creativity may be an important consideration for developing tools that can aid in or automate design processes. However, such cognitive models have not yet been widely considered for use in procedural content generation for games. This paper presents a framework for procedural content generation systems that use computational models of creativity as a part of the generative process. We demonstrate an example of such a system for generating instances for massively multiplayer, online role-playing games. The system combines the generative shape grammar formalism with a computational model of interest based on the Wundt curve to select new designs that are similar-yet-different to existing human designs. The approach aims to capture the usefulness and value of an existing human design while introducing novel or surprising variations through the model of interest. The system incorporates a metric that permits generated designs to be evaluated in terms of both their similarity to human designs and their novelty in the context of existing designs.

1. Introduction

Procedural content generation (PCG) is the programmatic generation or adjustment of the content of a computer game. Various aspects of PCG have been studied including online and offline PCG; PCG of different types of game content; and different classes of algorithms for PCG [1,2]. One of the key challenges for all kinds of PCG lies in the need not only to generate game content, but to judge and ensure the novelty, quality and cultural value of generated content. This includes factors such as the surprise-value of generated content as well as the usefulness of content in the context of a particular game design. This paper proposes an approach to this issue by presenting a framework for PCG that generates new designs in a manner that can capture the usefulness and value of existing designs while also introducing novel or surprising variations. Specifically, we describe, demonstrate and evaluate an example of such a system for generating instances for massively multiplayer, online role-playing games (MMORPGs).

Studies of human designers have identified that the ability to generate artefacts that are novel, surprising, useful and valuable are facets of the human cognitive capacity for creativity [3]. Thus, to achieve these aspects in a PCG framework we draw on models of design cognition and creativity in humans and artificial systems. The approach in this paper provides a framework for building PCG tools that can take components of high quality designs produced by human designers and creatively recombine, reuse and augment those components using artificial creative processes to generate new designs. The approach aims to incorporate two broad aspects of creativity. First, usefulness and value are captured in a new design by ensuring that there is similarity or 'closeness' between new designs and one or more existing human designs. Secondly, novel and surprising variations are introduced in new

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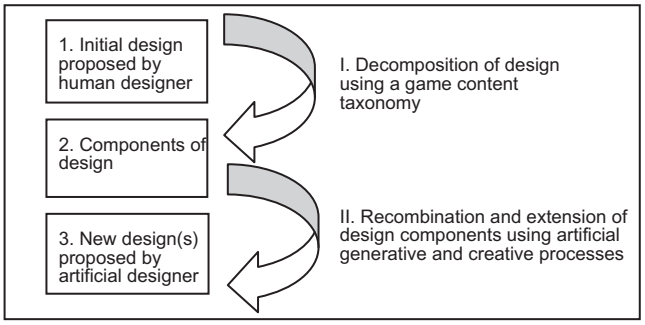

Fig. 1. A framework for computational creativity in procedural content generation.

designs using a computational model of interest to evaluate new designs.

Fig. 1 illustrates the high level framework for computational creativity in PCG proposed in this paper. First, to permit new designs to capture aspects of the usefulness and value of high quality human designs, our framework assumes the existence of at least one initial human design as a starting point for the creative process. This design is then decomposed (Step I) into primitive components that become the design variables input to the creative process (Step II). The creative process recombines those components to create new designs. This paper presents a tool that aids the human designer in Step I and automates the role of the human in Step II.

The remainder of this paper is organized as follows. Section 2 provides a cross-disciplinary review of literature in creative design and PCG. In Section 2.1 a number of generative algorithms and their role in PCG are briefly discussed. A detailed review of shape grammars is provided as background for the specific approach taken in this paper. As a basis for decomposing human designs into their constituent elements, Section 2.2 reviews existing taxonomies of the elements of game design. Section 2.3 reviews the elements of MMORPGs in particular, as the focus for the work in this paper.

Section 3 selects a subset of the elements of game content for MMORPG instances as the basis for a formal specification of our framework for computational creativity in PCG. Section 4 demonstrates an implementation of this framework and evaluates a set of designs for MMORPG instances it produces, including the design of the game space and the placement of non-player characters (NPCs) and interactive objects within the space. The paper concludes in Section 5 with a discussion of the implications and future directions of this work.

2. Background and literature review

The link between PCG in computer games and creative design lies in the recognition that PCG systems cannot simply generate new game content, but must also select only appropriate designs from generated content. Likewise, it has been recognized that creative design is concerned with more than just the introduction of something new into a design. While novelty is considered necessary for creativity, the introduction of 'something new' should also lead to a generated design that is somehow unexpected (surprising) as well as being useful, valuable or appropriate [4]. This link suggests that PCG systems must incorporate both generative and creative components. This assumption forms the foundation of the work in this paper. The following sub-sections thus review literature from both design cognition, and PCG to provide the background for the work in this paper.

2.1. Creativity and design

PCG can be thought of as automated design of all or part of a computer game. Broadly speaking, game design is the process of designing the environment, content, storyline and rules of a game. It can include the design of 3D objects and textures for buildings, terrain and NPCs as well as the design of dialog, scenarios, puzzles and stories. Design in a more general sense can be described as a process of purposeful, constrained decision-making, exploration and learning [4]. A design task – such as designing a character or building – can be conceived of as a problem space described by a set of variables. Decision-making processes select values for these variables from a solution space; exploration changes either the problem space or the solution space; and learning implies a restructuring of knowledge to reduce the distance between the problem and solution spaces.

The role of creativity in design has been studied from a number of perspectives [3]. From one perspective, creativity is considered to reside only in the generated design as it is evaluated by an individual or a society of users. From another perspective creativity is considered as a process that produces designs that may be evaluated as creative. This latter perspective informs research that seeks to produce artificial systems that can exhibit such creative processes, and is thus relevant to this paper.

A range of generative design approaches have so far been proposed for PCG in computer games. These approaches include pseudo-random number generators, generative grammars [5,6], image filtering, spatial algorithms, complex systems simulations and artificial intelligence algorithms [2]. There is currently some overlap of these approaches with those used in artificial systems that automatically generate creative design solutions based on models of creativity. However, the latter systems tend to focus on modeling the biological and cognitive phenomena associated with creativity, rather than on design generation alone. Examples of biologically inspired models include evolutionary systems and genetic algorithms [7,8], while examples of cognitively inspired models include analogy [9,10], novelty, interest and curiosity [11], situated reasoning [12], flexible ontology [13] and case-based reasoning [14,15]. These tools can be fully automated, or require interaction from [16] or collaboration among [17] designers.

The demonstration in this paper is an interactive tool that incorporates a model of creativity based on novelty and interest with a shape grammar system for PCG. These models are described in detail in the next two sections.

2.1.1. Computational models of novelty and interest as a basis for modeling creativity

Computational models of creativity – and associated models of novelty, interest and curiosity – have been developed by researchers in a number of domains [18]. This includes design science [11], developmental robotics [19] and computer games. Computational models of interest have been used for a number of purposes in game design. These include evaluating generated games [20], increasing the entertainment value of games [21] and controlling the behavior of NPCs in games [22]. In contrast, in this paper, Saunders' [11] model of interest is used as part of a model of creativity. Saunder's model is both flexible and modular, and thus lends itself well to adaptation to the PCG problem.

Saunders [11] proposed the model of interest in Eq. (1) as a model of creativity in design whereby artificial design agents can select design actions with the goal of generating moderately novel artifacts. Psychology literature suggests that there is an inverted U-shape relationship between novelty and interest [23,24]. That is, the most interesting experiences are often those that are moderately novel. Saunders [25] modeled interest I by first using a